Our Columbia Waters
Integrated Management Plan
Wastewater & Stormwater

Columbia Wastewater and Stormwater Integrated Management Plan

Final Report

HDR

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City of Columbia, MO

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https://www.como.gov/utilities/sewer/imp/

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Section 1. Introduction and Objectives

Over the past decade, population growth, aging infrastructure, increasingly complex water quality issues, and challenging economic conditions have strained municipal utility management across the country. This situation has been further complicated by federal and state regulatory structures that historically focused on enforcing individual Clean Water Act (CWA) requirements on fixed schedules, without full consideration of all obligations that a utility may be facing or whether compliance efforts will result in meaningful improvements in environmental and public health. These narrow regulatory processes limit a community's ability to efficiently manage their utilities because they must address new regulatory requirements on a "first come, first served" basis, rather than prioritizing affordable and protective solutions to resolve the most critical environmental and public health issues.

"The integrated planning approach does not remove obligations to comply with the CWA [Clean Water Act], nor does it lower existing regulatory or permitting standards, but rather recognizes the flexibilities in the CWA for the appropriate sequencing and scheduling of work."

From EPA's 2012 Integrated Municipal Stormwater and Wastewater Planning Approach Framework

In 2011, the US Environmental Protection Agency (EPA) recognized that when afforded the flexibility to balance wastewater and stormwater improvements, municipalities can make important cost effective environmental improvements that align with community priorities[1]. To support communities in these efforts, EPA released the *Integrated Municipal Stormwater and Wastewater Planning Approach Framework*[2] (Framework). The Missouri Department of Natural Resources (MDNR) also supports municipal integrated planning and has developed a similar framework[3]. EPA's framework outlines a process that allows municipalities to meet human health and water quality objectives by using existing CWA flexibilities to appropriately prioritize and schedule wastewater and stormwater improvements according to a community's needs and financial capability.

The City of Columbia, Missouri (City) initiated this Integrated Planning effort after multiple and significant regulatory challenges, and aging infrastructure demands highlighted the importance of balancing and prioritizing investments. In January 2011, the Missouri Department of Natural Resources (MDNR) initiated enforcement negotiations with the Sewer Utility Division for wet weather sanitary sewer overflows (SSOs). During this timeframe, MDNR and the US Environmental Protection Agency (USEPA) developed the Hinkson Creek Total Maximum Daily Load (TMDL) to address a biological impairment. The Hinkson Creek TMDL did not include specific pollutant wasteload allocations but rather established stream flow targets to restore the beneficial use. Urban stormwater discharged from the City's municipal separate storm sewer system (MS4), as well as the Boone County's and University of Missouri's MS4s, were considered significant pollution sources in the TMDL. The TMDL resulted in the creation of the

[1] Stoner, N. and C. Giles. 2011. Achieving Water Quality through Integrated Municipal Stormwater and Wastewater Plans. October 27, 2011. Washington DC.
[2] Stoner, N. and C. Giles. 2012. Integrated Municipal Stormwater and Wastewater Planning Approach Framework. June 5, 2012. Washington DC.
[3] Hirschvogel, Lacey. 2016. Missouri Integrated Planning Framework. Water Protection Program. Jefferson City, MO.

Collaborative Adaptive Management (CAM) process that the City is currently implementing in coordination with EPA, MDNR, Boone County, and the University of Missouri. With these two impactful regulatory drivers alone, the City realized that the community may ultimately face unaffordable program costs with typical regulatory implementation requirements, which would be exacerbated by additional regulatory obligations and the City's other infrastructure challenges.

In addition to these two significant regulatory issues, the City also faces a number of future issues (**Attachment A**) and service demands that will continue to impact wastewater and stormwater infrastructure decisions and investments for the next several decades. When EPA's Framework was issued, the Columbia City Council, Mayor, and Utility managers recognized that it provided a means to address existing and future regulatory requirements while continuing to meet the needs of the systems operations and chose to use it to develop this Integrated Management Plan (IMP). In 2017, the City and MDNR executed a Memorandum of Understanding (MOU) which acknowledged that the City would prepare the IMP to prioritize future wastewater and stormwater improvements (**Attachment B**) and MDNR would use the IMP recommendations in future regulatory and permitting decisions.

Integrated planning allows the City to proactively and affordably balance and prioritize regulatory issues and infrastructure needs

The City retained HDR Engineering, Inc., and their team, which includes Geosyntec Consultants, Inc., Shockey Consulting Services, LLC, Black and Veatch, Inc., and TREKK Design Group, LLC (collectively, the Project Team), to assist in developing the IMP. This planning effort is focused on developing a prioritized and balanced infrastructure investment strategy to address wastewater and stormwater management needs, including programmatic and capital funding for the wastewater collection, wastewater treatment, and stormwater management programs.

In their Framework, EPA recognizes that integrated plans should be appropriately tailored to the size of the municipality and scope of the issues, but they anticipate that all integrated plans will address the following six planning elements:

- **Element 1 –** A description of the water quality[4], human health and regulatory issues (**Attachment A**) to be addressed.
- **Element 2 –** A description of existing wastewater and stormwater systems under consideration and summary information describing the systems' current performance.
- **Element 3 –** A process which opens and maintains channels of communication with relevant community stakeholders in order to give full consideration of the views of others in the planning process and during implementation of the plan.
- **Element 4 –** A process for identifying, evaluating, and selecting alternatives and proposing implementation schedules.
- **Element 5 –** A process for evaluating the performance of projects identified in a plan.
- **Element 6 –** An adaptive management process for making improvements to the plan.

Columbia's IMP project approach

To develop this IMP, the City and the Project Team tailored an approach that aligns with EPA's six elements and allows the City to affordably meet CWA requirements (**Attachment A**) while planning for infrastructure investments over the next 20 years (**Attachment C**).
The City envisions implementing the IMP in a phased manner to address the most critical existing infrastructure and regulatory drivers first, while allowing adequate time to gather the information needed for thoughtful infrastructure planning. As discussed in **Section 4.2** below, critical needs were identified and prioritized based on their anticipated environmental, social, and economic benefits. Using this approach, the City will have an adaptable plan that addresses current regulatory drivers, provides investment certainty over the next 5 to 10 years, accounts for necessary non-regulatory investments prior to taking on investments to deal with future regulations, and defines affordability for the City's ratepayers.

This IMP also builds on previous sewer and stormwater planning efforts undertaken by the City. In 2004, the City completed wastewater master planning efforts[5] to identify capital improvement projects and funding needed to address anticipated collection and treatment needs through

[4] Throughout this report, the term "water quality" refers to surface water (streams, rivers, and lakes) quality.
[5] https://www.como.gov/utilities/wp-content/uploads/sites/20/2016/09/ColumbiaSewerMasterPlan-Nov2004.pdf

2030. The City completed a similar stormwater assessment[6] in 2008 and finalized a rate study[7] in 2014 to identify revenue needs to satisfy forecasted annual operating, debt service, and capital requirements for the Storm Water Utility. The City recognizes that although these wastewater and stormwater plans continue to be useful planning documents, the recommendations must be reviewed periodically to account for changes in customer growth and economic projections, facility and program needs, and regulatory requirements.

In August 2015, the City formed the Mayor's Task Force on Infrastructure (MTFI) to broadly review and identify the City's overall infrastructure needs. The MTFI evaluated the overall operation, maintenance, and funding of the stormwater system, sewer system, downtown electric system, and major street plan and transportation infrastructure. The MTFI also reviewed past planning efforts, as well as current and future project priorities for these programs. The MTFI also provided both functional recommendations and financial/policy recommendations for the City Council and staff to consider. The functional recommendations were considered during the development of this IMP and incorporated where reasonable and appropriate. The majority of the MTFI financial and policy recommendations were beyond the scope of the IMP and were not evaluated. A summary of the functional recommendations and how they were addressed by the IMP is included in Section 7.

Details regarding the overall planning approach, as well as supporting data, information, and analyses used to inform the final IMP recommendations and actions are documented throughout the remainder of this report. A copy of this final report, as well as technical memoranda and community outreach materials, are available at www.como.gov/utilities/sewer/imp/.

6 https://www.como.gov/utilities/stormwater-engineering/2008-stormwater-utility-assessment/
7 Burton and Associates, Inc., 2014. City of Columbia Stormwater Utility Rate Study. September 30, 2014.

Section 2. Build the Vision

Element 1 of EPA's framework involves identifying the important regulatory, environmental, human health, and infrastructure issues that will be addressed in the planning process. To build a cohesive vision for the IMP, the City hosted a two-day visioning workshop in May 2016 to discuss existing and future challenges facing the City, goals and objectives of the IMP, and potential IMP strategies to meet those goals (**Attachment D**). Workshop participants included representatives from a number of City Departments, including: City Management, Utilities Department, Columbia/Boone County Public Health and Human Services, Finance Department, Sustainability Office, Legal Department, and Community Relations. Representatives from the University of Missouri, Boone County, and the Boone County Regional Sewer District also participated. The City Council and Mayor were also individually interviewed to capture the critical issues and desired outcomes for the IMP process.

Over the course of the two-day workshop, the group discussed issues that would impact IMP development such as anticipated state and federal regulatory drivers, affordability concerns and strategies for characterizing ratepayer impacts, current conditions and future expectations for the City's wastewater and stormwater systems, and key stakeholder groups that should be included in the process. Through these discussions, the group broadly characterized goals, priorities, and challenges to inform the IMP. These ideas were captured in a vision statement intended to clearly and effectively communicate the intent and desired outcomes of the IMP to community stakeholders.

Columbia IMP Vision Statement

The stormwater and wastewater Integrated Management Plan is a community-driven, affordable infrastructure plan that enhances human health and safety, water quality, economic vitality, and environmental resources by leveraging existing assets and implementing innovative solutions.

To achieve this vision and guide the successful development of the IMP, workshop participants identified several key considerations that should be addressed during the planning process.

- Regulatory uncertainty is one of the largest challenges facing the City. The plan should provide at least five years of regulatory certainty so that the City can conduct important system condition assessments, develop asset management tools, and undertake other improvements that are necessary to develop an effective, long-term asset management and capital improvement program.
- Financial impacts on all City ratepayers, and specifically disadvantaged communities, must be carefully considered as IMP alternatives are developed or implemented.
- Integrated planning is a community-driven process. Therefore, stakeholder and community involvement is critical to developing an effective IMP. As part of the community engagement effort, the City should obtain input from a wide variety of stakeholders. Project information should also be developed so that the community can

easily understand the known problems and how the proposed projects will address these problems and provide additional benefits.

- The IMP recommendations should focus on identifying projects that have multiple benefits and are technically-feasible, prioritized, funded, and supported by the community. Specifically, the IMP will be successful if it provides a means to implement currently planned, critical infrastructure projects over the next five years and positions the City to successfully plan for and meet long-term environmental and infrastructure goals. In the near term, the IMP should focus on the most critical wastewater and stormwater priorities, which include:
  - Developing and implementing an asset management system to support system renewal efforts, identify performance baselines, measure progress, and assist in communicating infrastructure needs to ratepayers;
  - Addressing wet-weather issues, particularly basement backups, SSOs, and areas with persistent inflow and infiltration (I/I) challenges;
  - Reducing capacity-related issues in the existing wastewater treatment and collection systems; and
  - Improving stormwater planning, education, outreach, and inter-departmental coordination in an effort to formalize projects needed to address known drivers and accurately characterize future funding needs.

The visioning workshop was an important first step in the IMP development process because the vision, goals, and considerations identified helped to focus planning activities and shape the overall direction and objectives of the plan.

Feedback received during the two-day IMP visioning workshop shaped the overall direction and objectives of the plan

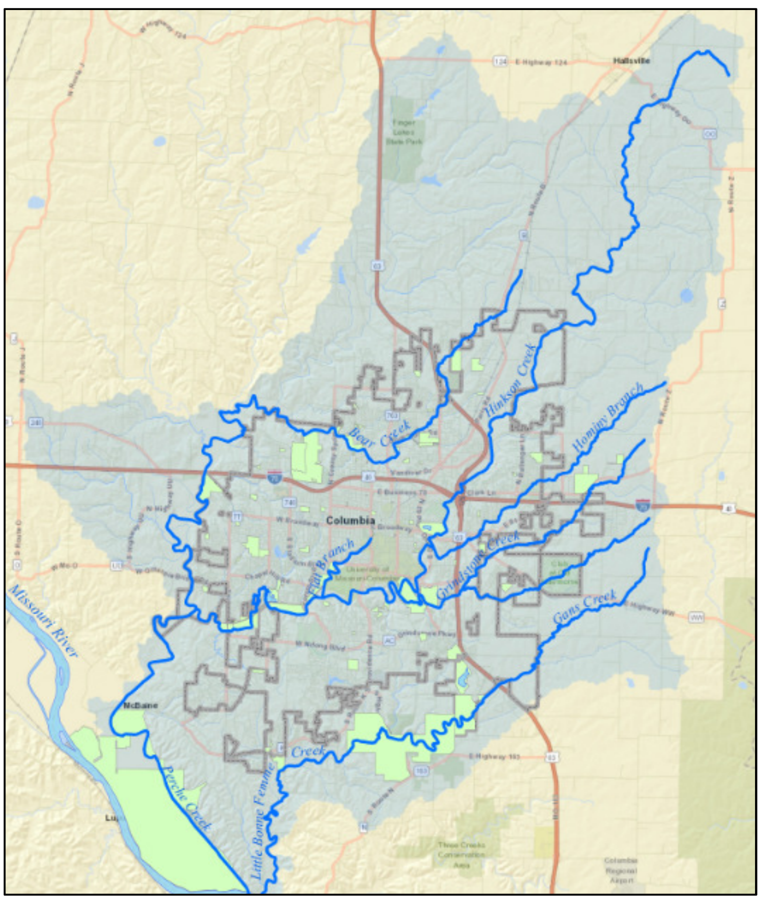
Section 3. Existing System Evaluation

The next step of the planning process includes evaluating the City's environmental resources and infrastructure assets to better define the existing condition, performance, and needs of its systems. This step directly addresses Element 2 of EPA's framework and forms the basis for developing alternatives (Element 4) and performance tracking systems to measure progress (Element 5) during future IMP phases.

To develop a comprehensive understanding of existing conditions, the City and their Project Team compiled and evaluated existing surface water quality and biological condition (**Attachment E**), wastewater collection (**Attachment F**), wastewater treatment (**Attachment G**), and stormwater management (**Attachment H**) data. For a detailed description of the data, performance assessments, and identified data gaps, refer to the corresponding technical memoranda attached to this report. Summaries of these evaluations are included below.

3.1 Surface Water Quality Conditions in Columbia

Columbia is widely known for its urban area streams, lakes, and wetlands and natural areas. There are approximately 300 miles of streams and more than 100 public and private lakes within the 200 square miles of watersheds that adjoin or intersect the City. The Missouri Department of Conservation's (MDC) Eagle Bluffs Conservation Area (Eagle Bluffs) is a regional natural resource asset and is supported by treated effluent from the Columbia Regional Wastewater Treatment Plant (CRWWTP). The City's water resources are prominent natural features that support wildlife habitat and recreational opportunities. Therefore, understanding current water quality conditions in Columbia area streams is critical for establishing priorities through the IMP process.



Quality of life in the Columbia area is improved by the numerous water and natural resources

The State of Missouri has established water quality standards for streams, lakes, and wetlands across the state. These standards are implemented by MDNR and specify water quality conditions that are protective of both aquatic life and public health. If water quality standards are not met, the City may be required to take corrective action if the impairment is attributed to activities within the City's jurisdictional area.

There are a number of streams and lakes in Columbia that MDNR has identified as impaired because conditions do not meet water quality thresholds intended to protect designated beneficial uses. Designated beneficial uses associated with waters in the Columbia area include: whole body contact recreation or swimming, secondary contact recreation such as fishing or wading, protection of warm water aquatic life, protection of human health-fish consumption, and livestock and wildlife watering. The most common impairment in the Columbia area is for whole body contact recreation, or swimming. These recreational impairments are related to high bacteria levels that may pose health risks to users.

Beneficial uses of several regional streams and lakes are considered impaired due to unsatisfactory water quality conditions

Waterbody	Impaired Designated Beneficial Use	Impairment Source	Pollutant	Impairment Status
Hinkson Creek	Swimming and Wading	Nonpoint and Urban Runoff	Bacteria	Awaiting TMDL
Hinkson Creek	Aquatic Life Support	Nonpoint and Urban Runoff	Unknown	Approved TMDL & CAM Process Initiated
Hominy Branch	Swimming and Wading	Nonpoint and Urban Runoff	Bacteria	Awaiting TMDL
Grindstone Creek	Swimming and Wading	Nonpoint and Urban Runoff	Bacteria	Awaiting TMDL
Little Bonne Femme Creek	Swimming and Wading	Unknown	Bacteria	Awaiting TMDL
Perry Phillips Lake	Human Health Protection	Atmospheric Deposition	Mercury	Awaiting TMDL
Lake of the Woods	Human Health Protection	Atmospheric Deposition	Mercury	Awaiting TMDL

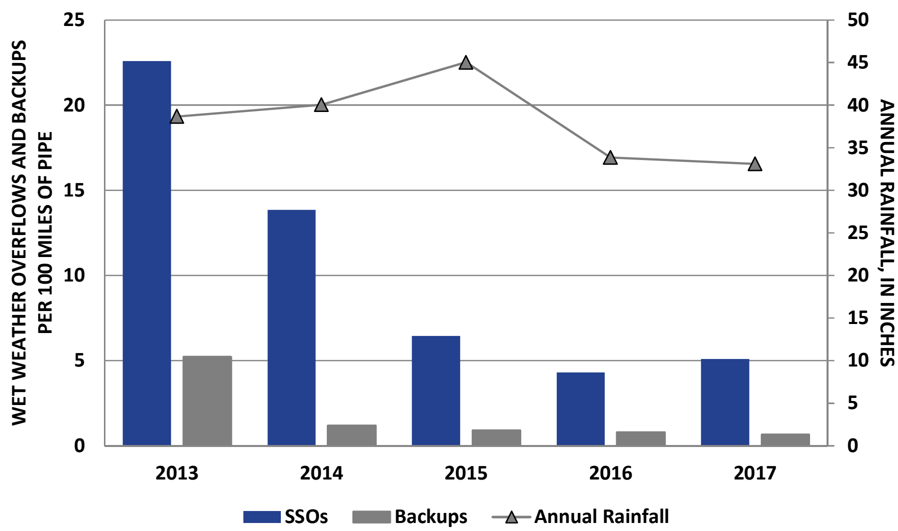
In addition to reviewing existing impairments, the Project Team compiled data from accessible, publicly-available sources to facilitate characterization of water quality conditions in and around Columbia. The water quality database included more than 17,000 data records from over 100 monitoring locations in Columbia watersheds. Most of the historical data were collected from the main stem of Hinkson Creek but are not robust or consistent throughout the remaining watersheds. Although these data were sufficient for evaluating large scale patterns and trends, the limited data available from most sites generally prevented detailed analysis needed to identify potential pollution sources or areas of concern.

Results of the data analysis indicated that the current list of impaired waters adequately characterizes the existing water quality concerns in Columbia. In general, elevated bacteria levels are the most pervasive issue throughout Columbia area waters. These high levels are exacerbated following rainfall events that contribute runoff to the streams. Significant or widespread impacts caused by other parameters such as low dissolved oxygen, chloride, and nutrients were not apparent from the data.

3.2 Wastewater Collection System Review

The wastewater collection system is an important component of the infrastructure owned and operated by the City's Sewer Utility. Effective management of the collection system is vital for meeting important goals like reducing SSOs, achieving regulatory compliance, efficiently managing wastewater, and improving customer satisfaction. The Project Team worked with City staff to review the existing program and characterize the City's current collection system management strategies and practices in the context of good engineering practices and core attributes that are fundamental to effectively managing and operating sanitary collection systems.

The collection system performance review indicated that City's program has consistently improved over time and is meeting or exceeding expectations associated with an effectively managed Utility. For example, the City has made significant progress addressing overflows and building backups that occur during major wet weather events through a combination of operational improvements at the CRWWTP influent pump station, I/I reduction efforts, and capacity improvement projects. Although the influent pump station continues to be a significant hydraulic restriction during wet-weather events, these improvements dramatically reduced surcharging and SSOs in the collection system upstream of the CRWWTP in 2015.



The Sewer Utility has implemented effective measures to reduce overflows and backups from Columbia's sanitary sewer system

While the City has made significant improvements in the collection system, a number of capital and programmatic needs and data gaps were identified during the wastewater collection system assessment. According to the assessment, the City should:

- Develop and implement strategies to support system renewal and maintenance efforts using an asset management approach, including a mechanism to establish sufficient dedicated funding for these efforts.
- Develop a hydraulic model to identify improvements that will address remaining system capacity limitations and reduce I/I, building backups, and SSOs caused by wet weather flows.

- Maintain collection system maintenance performance to limit dry weather backups and SSOs due to blockages despite the challenges presented by aging infrastructure and community growth. Ensure adequate funding is available to achieve this performance.
- Update collection system goals to ensure they reflect the City's short and long-term priorities. Progress towards achieving these goals could be measured through actionable Key Performance Indicators (KPIs) that support the City in making business decisions, allocating resources, and identifying challenges that could negatively impact performance and service levels.

Planning level alternatives to address these needs are included in **Section 5** of this report.

3.3 Wastewater Treatment System Review

Wastewater treatment is an essential service provided by the City and is critical for protection of human health and regional water quality. The CRWWTP treats residential, commercial, and industrial wastewater generated within the Columbia metropolitan area and is one of the City's most significant infrastructure assets. The CRWWTP's ability to comply with current and future regulations, while managing wastewater from a growing population, was a vital consideration for the City during the IMP development process.

The CRWWTP consists of a mechanical treatment plant followed by a series of four treatment wetlands units that provide additional wastewater treatment. The constructed treatment wetlands are a unique feature of the CRWWTP. Constructed treatment wetlands use natural physical, biological, and chemical processes to remove a wide array of wastewater pollutants, including organics, nutrients, ammonia, metals, and bacteria. Treated effluent from the CRWWTP is discharged into Eagle Bluffs to provide a valuable water source for wildlife habitat.

The Columbia Regional Wastewater Treatment Plant is a critical asset to effectively manage and treat wastewater from the City and surrounding area

Since the CRWWTP was initially constructed in 1983, more than 100 small WWTPs have been eliminated in Columbia. The CRWWTP continues to be an important regional asset that is effectively used to manage and treat wastewater generated from this growing community. Currently, there are 38 domestic and 8 industrial wastewater treatment plants in or near Columbia. Of the 38 domestic National Pollutant Discharge Elimination System (NPDES) permits, 11 are decommissioning and joining either the CRWWTP or Boone County Regional Sewer District (BCRSD) systems.

In 2013, the City completed a $64 million upgrade and expansion of the CRWWTP. The upgrade was necessary to meet more stringent ammonia limits established by MDNR in the City's discharge permit. The upgrade also increased the capacity of the CRWWTP from a design average flow (DAF) of 20.6 million gallons per day (MGD) to 25.2 MGD. The project included the addition of two new mechanical plant treatment trains and improvements to the headworks, wet wells, grit removal system, solids handling, and various upgrades intended to improve treatment efficiency, effectiveness, and health and safety protections.

With the CRWWTP upgrade, effluent quality has dramatically improved. Specifically, discharged ammonia, biochemical oxygen demand, and bacteria concentrations have decreased and are maintained at levels necessary to support aquatic life and secondary contact recreational uses in Eagle Bluffs. The CRWWTP has also consistently complied with discharge permit limits implemented by MDNR.

The CRWWTP is currently producing a high quality effluent, but the City understands that it is appropriate to plan for future treatment system needs that will improve existing operations; address anticipated regulatory drivers related to the wet-weather program, disinfection, nutrient removal, and more stringent ammonia limits; and continue to provide for efficient and effective regional treatment services. Planning level alternatives to address these needs are included in **Section 5** of this report.

3.4 Stormwater System Review

Effective management and efficient implementation of the stormwater program is necessary for meeting important environmental and public safety goals such as improving water quality, minimizing flooding impacts, and reducing property damage. To develop a better understanding of the City's existing stormwater assets, the Project Team compiled relevant data and worked with the City to inventory the existing system, review its performance, and evaluate system capacity. More specifically, the Project Team characterized the number, size, and probable condition of existing stormwater conduits and structures; evaluated historical drainage and flooding issues; and reviewed conveyance system capacity design standards. From a water quality and regulatory perspective, the Project Team assessed the City's ability to maintain compliance with the requirements of their municipal separate storm sewer system (MS4) permit. This MDNR-issued permit outlines provisions for how the City must develop, implement, and enforce their stormwater management program and plan to reduce pollutant discharges to the maximum extent practicable.

Stormwater system failures contribute to public health, safety, and water quality concerns across Columbia

Most critically, the evaluation highlighted the fact that the current level of asset management investment is not sufficient to address existing and future needs. Currently, approximately 15% of pipes in the system are likely beyond their physical effective life. This number is expected to grow to nearly 60% over the next 20 years at the current renewal rate. The assessment findings also indicated that only 1% of the pipes and 7% of the structures have been inspected and assigned a condition rating. The City currently spends a portion of the annual storm water budget addressing failing pipes and inlets. Continued underfunding and deferment of system replacement, renewal, and assessment activities will further reduce system function and reliability.

These asset renewal issues contribute to public health, safety, and water quality concerns. Yard, street, and house flooding is an important health and safety concern for the City because these issues can affect the integrity of other infrastructure such as roads and sewer lines. Collapsing storm pipes and roadway failures can also impact water quality in area streams and lakes, which is a significant concern for the Storm Water Utility because there are seven water quality impairments in the City that are identified as being caused by urban and other nonpoint source runoff.

To address water quality issues, the City has developed a joint stormwater management plan (SWMP) under their MS4 permit in coordination with Boone County and the University of Missouri. The SWMP reflects federal (40 CFR 122.34) and state (10 CSR 20-6.200(5)(A)1-6)) regulations which requires the City to implement six minimum control measures (MCMs) to protect water quality and effectively reduce stormwater runoff to the maximum extent practicable. The six minimum controls are: public outreach and education, public involvement and participation, illicit discharge detection and elimination, construction stormwater runoff control, post-construction stormwater management in new development and redevelopment, and pollution prevention and good housekeeping for municipal operations.

The City and their co-permittees are currently fulfilling the requirements of the MS4 permit. However, the evaluation highlighted several opportunities for improvement in the current program. Most notably, developing a more strategic and proactive illicit discharge detection and elimination inspection program and refining erosion and sediment control inspection operations would allow the City to more effectively resolve issues that cause immediate water quality concerns.

The stormwater system review also identified a number of gaps and limitations related to management of the existing system data and database. The City is aware of these issues and has been working to advance their data collection, tracking, and maintenance procedures but continued and better-funded efforts will help improve future stormwater system planning, maintenance, and performance.

Planning level alternatives to address identified stormwater needs are included in **Section 5** of this report.

Section 4. Community Outreach

Effective outreach is a vital component of the planning process since the community's input directly informs development of the IMP. During the outreach process, the Project Team educated participants by highlighting important infrastructure, environmental, and public health needs; consulted participants to gain an understanding of community needs; and involved participants by working with them directly throughout the process to identify criteria by which to measure the benefit of potential solutions. Through early and continuous outreach, the City brought diverse perspectives and values into the decision-making process and strived to ensure that concerns and needs were thoroughly considered. This outreach process will result in an IMP that incorporates community goals and values.

The Columbia IMP was developed with robust community input using multiple methods of engagement

Element 3 of EPA's Framework suggests that municipalities pursue the following principles when conducting integrated planning outreach activities:

- Provide appropriate opportunities that allow for meaningful input during the identification, evaluation, and alternative selection phases of the planning effort,
- Make new information available and provide opportunities for input into the development of proposed modifications of the plan, and
- Allow public involvement to assist in evaluating the opportunities and effectiveness of potential green infrastructure alternatives, if they are relevant to the plan.

The Project Team worked with City staff to implement an engagement strategy (**Attachment I**, **Attachment J**) that described the planning process, provided for continuing input by stakeholders, and ensured that stakeholder concerns received fair consideration. The approach was intended to bring a diverse group of stakeholders together, educate them regarding various options, and gather input in a structured, inclusive, and transparent process. In the context of EPA's Framework, community outreach should be an ongoing process that is used inform and refine IMP goals and outcomes over time. Therefore, the City expects that IMP implementation will be reviewed through outreach activities such as an open comment period and public hearings and Columbia City Council meetings.

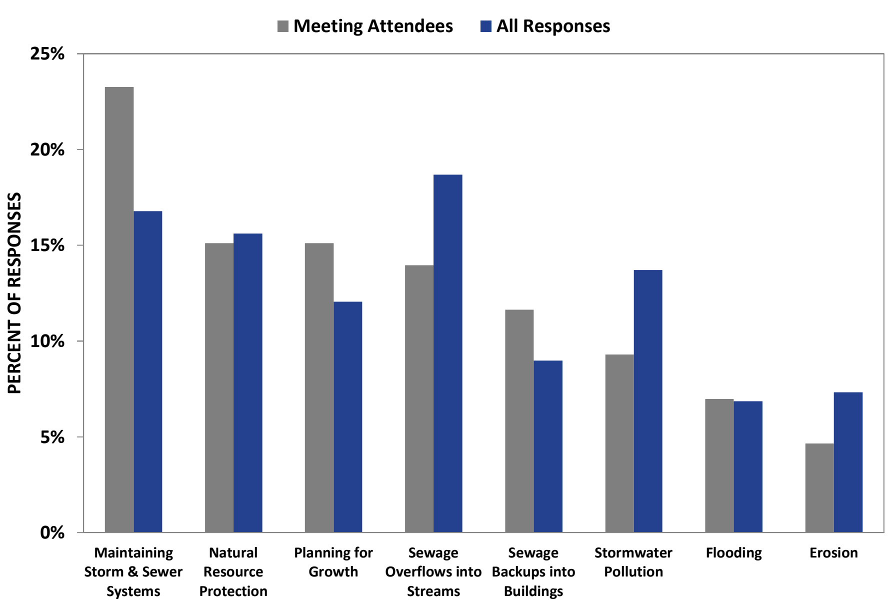
4.1 Stakeholder Involvement

IMP Workshops provided an opportunity to inform the public about wastewater and stormwater infrastructure issues and capture community priorities

In addition to the general public, the Project Team identified key stakeholders from a balance of interests across the community. These stakeholders included representatives from the Columbia City Council, government agencies, representatives of economically and socially disadvantaged populations, environmental and conservation groups, the business and development community, nonprofit and civic organizations, large impervious surface property owners, and residents who have experienced chronic building backups. The team reached out to specific organizations within these groups in an attempt to get a wide variety of participation in the planning process. Overall, more than 160 members of the community participated or provided input into the planning process.

4.2 IMP Outreach Activities

Outreach efforts with the general public focused on preparing and providing relevant information to educate the community at large and getting high-level, value-based input from interested stakeholders. The activities included distributing project fact sheets to introduce the IMP, share the desired outcomes, and provide opportunities for the public to get involved; maintaining a project website; and issuing press releases and social media posts to notify the public of opportunities to provide input. The project website has since been incorporated into the City's website: https://www.como.gov/utilities/sewer/imp/.



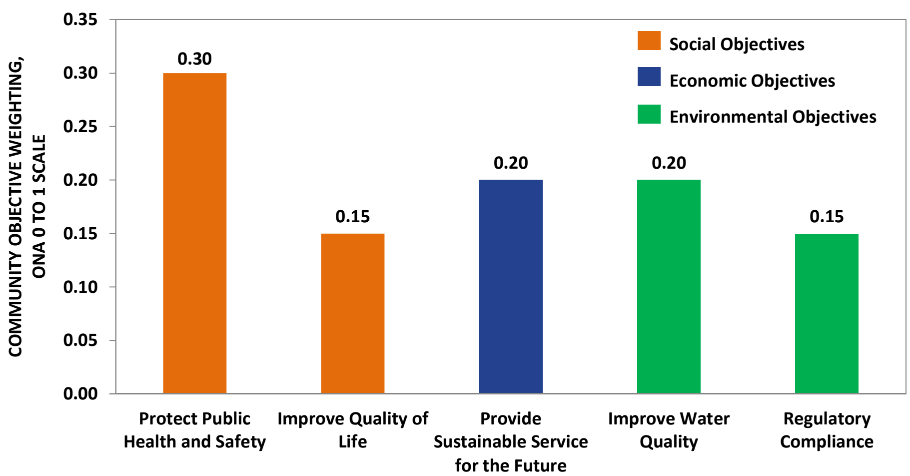
Workshop and survey participants provided important input on infrastructure, public health, and water quality priorities that should be addressed in the IMP

In addition to these broad outreach efforts, the Project Team developed an online survey and conducted a series of four workshops; 162 people participated in the survey and 77 individuals attended at least one community workshop. The goal of these efforts was to obtain specific input on the infrastructure, water quality, and public health needs that should be addressed by the IMP (Workshops #1 and #2); review potential solutions (Workshop #2); discuss the resources needed to implement the solutions affordably (Workshop #3); and outline the process and decision criteria used to evaluate project costs and benefits (Workshop #4).

The City and Project Team also met with Council members throughout development of the IMP so that they were informed about the planning process. Each Council member was invited to meet, both individually and in pairs, and discuss the planning process; these meetings were held early during the Visioning phase of the project to ensure that each person's priorities were captured in the plan and then later to discuss the engineering alternatives, costs, and potential ratepayer impacts associated with addressing those priorities. A preliminary draft of this IMP was presented to the Council during a work session on August 7, 2017. Prior to finalizing the IMP, the City also offered a 30-day public comment period to solicit additional input and allow the public to review recommendations included in the plan.

4.3 Applying Outreach Results to the IMP

Feedback received over the course of the IMP outreach indicated that maintaining storm and sewer systems was the highest programmatic and infrastructure-related priority for Columbia stakeholders. However, other issues such as natural resource protection, planning for growth, reducing building backups and sewage overflows into streams, and flooding were also important issues to participants. Although all waterbodies in and around Columbia are important to Columbia residents, Hinkson Creek and its tributaries, Eagle Bluffs, and regional high quality streams such as Bonne Femme and Little Bonne Femme Creeks are generally valued highest.



IMP community outreach provided social, environmental, and economic – the triple bottom line – priorities and weightings for informed decision making

Based on this information and other feedback received from the survey, workshops, and City Council coordination described above, the Project Team used a triple bottom line approach to develop a series of weighted objectives that captured the community's social, economic, and environmental goals for the IMP. These five objectives were used as the primary decision criteria for evaluating potential IMP wastewater and stormwater alternatives to ensure that all potential community needs and priorities were considered in the planning process.

Section 5. Alternatives Analysis

Element 4 of EPA's Framework includes the identification, evaluation, and selection of alternatives and implementation schedules for system and water quality improvements. For Columbia, these solutions were developed based on the outcomes of the Visioning Workshop, existing system performance assessment, and community outreach program. This element is by far the most complex step in the planning process, as the goal is to identify alternatives that could meet all of those needs effectively and affordably. The Project Team's approach for identifying and optimizing alternatives, as well as the proposed implementation schedule for those alternatives, is summarized below.

5.1 Identifying Alternatives

The goal of the alternatives identification process was to develop planning level project descriptions and cost estimates to characterize the additional level of investment required to address system needs, anticipated regulatory drivers, and City goals over the next 20 years (the IMP planning period). This step included outlining alternatives for the wastewater collection (**Attachment K**), wastewater treatment (**Attachment L**), and stormwater management programs (**Attachment M**). To facilitate this evaluation, wastewater and stormwater alternatives were grouped and analyzed by project category.

Wastewater and stormwater program alternatives were assessed by project category to characterize long-term IMP investment needs

Wastewater Treatment	Wastewater Collection	Stormwater Management
• Wet Weather Improvements • Expanded Nitrification • Biological Nutrient Removal • Chemical Disinfection • Constructed Wetlands Maintenance • Digester Rehabilitation • Digester Capacity Improvements	• Wet Weather Program Planning • Asset Management • System Renewal • System Capacity • Reducing Building Backups • Private Common Collector Elimination • System Expansion • Cleaning Program • Pump Station Repair • Annual Sewer Improvements	• Stormwater Planning • System Assessment and Cleaning • System Renewal • Flood Control • Stream Erosion • Runoff Treatment to Improve Water Quality • Stormwater Management Program

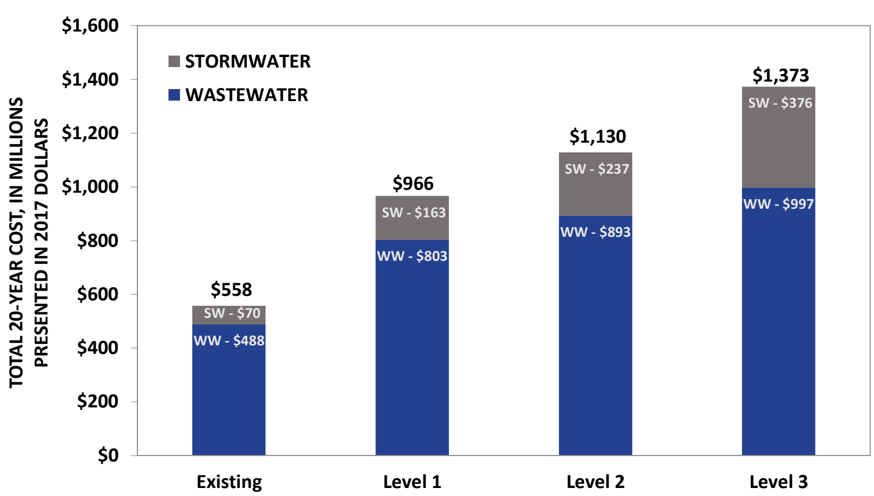
Cost estimates were developed for each project category to quantify the investments and resources needed ***in addition to*** those already expended by the Sewer and Storm Water Utilities. The planning level cost estimates included potential additional capital costs, operation and maintenance costs, and costs associated with necessary planning or data collection activities needed over the 20-year IMP planning period.

The three potential funding scenarios used to guide the cost analyses for each project category were broadly defined as follows:

- **Level 1 Funding (Level 1) –** Funding needed to **provide the minimum** level of service that meets both community-wide expectations and **existing** regulatory requirements over the 20-year IMP planning period.
- **Level 2 Funding (Level 2) –** Funding needed to **exceed the minimum** level of service that meets community-wide expectations and **more proactively** meets existing regulatory requirements over the 20-year IMP planning period.
- **Level 3 Funding (Level 3) –** Funding needed to **address all** forecasted infrastructure needs, and proactively meet **both** existing and forecasted regulatory requirements over the 20-year IMP planning period.

The project categories and funding assumptions were refined during a series of workshops between the Project Team and the City's Sewer and Storm Water Utilities. Specific methodologies and assumptions used to develop funding level estimates for each of the project categories, as well as detailed cost forecasts, are described in more detail in the corresponding technical memoranda attached to this report (**Attachments K, L, and M**). Given the uncertainties and data gaps identified during the existing system evaluation described in **Section 3**, the alternatives and costs identified for the IMP were only intended to serve as planning level estimates. These alternatives and associated costs should be refined as additional information is developed during future phases of the IMP.

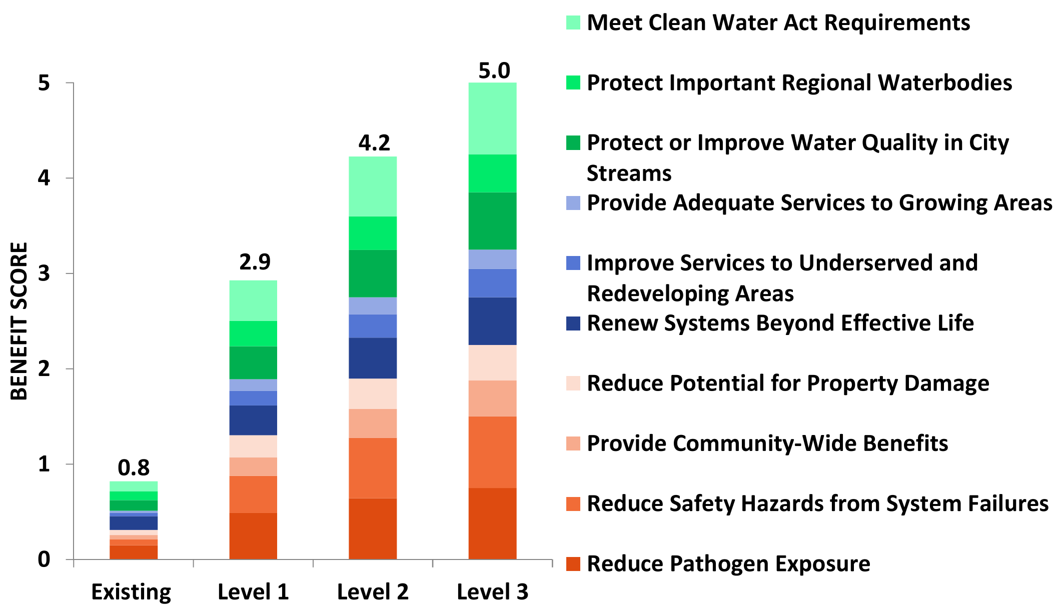
The alternatives analysis identified three potential funding levels to address system needs, regulatory drivers, and customer expectations



The City's existing (as of 2017) annual Sewer and Storm Water Utility budgets were approximately $24.4 million and $2.4 million, respectively, with stormwater set to increase through 2020. If the City were to maintain the existing programs and associated levels of funding over the 20-year IMP planning period, the City's total investment (in 2017 dollars) for wastewater and stormwater would be approximately $488 million and $70 million, respectively. The funding scenarios evaluated as part of the alternatives identification process indicate that significant additional investments would be needed to address system needs, regulatory drivers, and customer expectations over that same timeframe. According to the analysis, total costs to meet wastewater and stormwater needs over the next 20 years are potentially between $966 million and $1.37 billion.

5.2 Optimizing Programs to Maximize Community Benefits

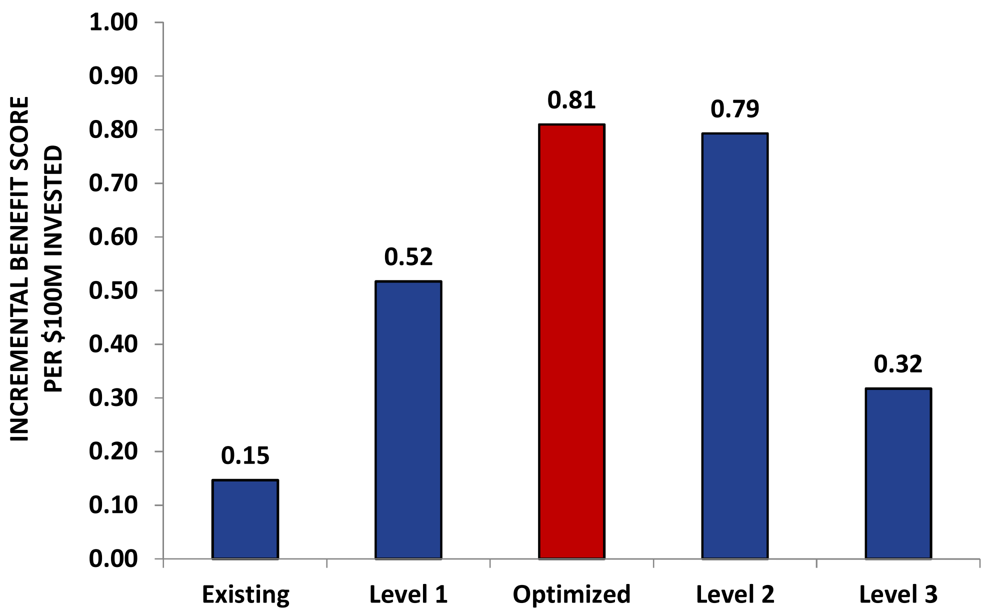
To determine which funding level alternative appropriately balanced costs with community objectives over the 20-year IMP planning period, the Project Team applied a multiple criteria decision analysis (MCDA) tool to calculate a total benefit score that represented the anticipated value that each alternative would produce for the community. Community priorities established through the outreach program were the primary decision criteria used and formed the basis for the MCDA scoring process. Using the MCDA tool (**Attachment N**), the Project Team rated each of the funding level alternatives relative to those community priorities with a standardized rating system and final scores were normalized using a 0 to 5 scale. The MCDA results indicate that each potential IMP funding level produces varying degrees of community benefits.



Columbia's IMP funding level alternatives deliver varying degrees of community benefits

Cost-effectiveness is a critical consideration in selecting a balanced and prioritized suite of wastewater and stormwater management alternatives. According to the benefits analysis, the greatest increase in benefit occurs when moving from the Existing funding to Level 1 funding (2.1 point increase). However, this increase in benefit must be evaluated with respect to the increased cost to implement the alternatives. When assessed in this way, results showed that Level 2 funding is the most cost-effective alternative because it produces the greatest benefit (0.79 points) for every $100 million dollars of total cost.

The Project Team recognized that although Level 2 funding had the highest benefit to cost ratio, an Optimized suite of alternatives could be developed by combining the project categories that provided the best value from among the four funding levels. On a per dollar basis, this Optimized suite of alternatives produced marginally greater benefit than the Level 2 funding alternative (0.81 points vs. 0.79 points) while costing $114 million dollars less over the 20-year planning period. Due to the reduced cost of this best value suite of alternatives, the Optimized suite of alternatives is the preferred program portfolio for the IMP.



The Optimized suite of IMP alternatives produces the greatest overall benefit to the community

5.3 Residential Affordability and Socioeconomic Evaluation

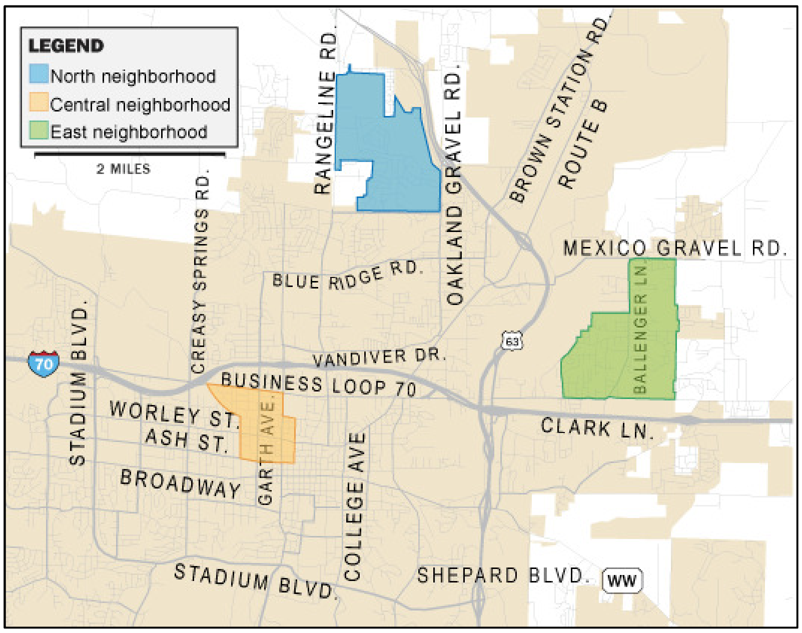
The MCDA evaluation was limited to quantifying the costs and benefits of potential alternatives and did not assess the impact of the increased cost of Utility services on the City's customers. Before committing to the implementation of the Optimized suite of alternatives, the City evaluated its impact relative to community socioeconomic conditions and average residential monthly bills to confirm that forecasted financial impacts would be affordable to residential customers (**Attachment O**).

Both EPA and MDNR allow communities the flexibility to consider financial and economic impacts and affordability when developing implementation schedules for integrated planning or permitting purposes. Historically, the affordability analysis tools that regulators have relied upon are narrowly-focused and did not provide communities sufficient flexibility to fully consider local socioeconomic considerations that may impact the financial capability of the municipality and customers. Recent guidance issued by both EPA[8] and MDNR[9] however, has clarified expectations for municipalities conducting affordability analyses in the context of an integrated

[8] Kopocis, K., and C. Giles.2014. Financial Capability Assessment Framework for Municipal Clean Water Act Requirements. Office of Enforcement and Compliance Assurance. Washington, D.C.
[9] Hirschvogel, L. 2016. Missouri Integrated Planning Framework. Water Protection Program. Jefferson City, Missouri.

plan. These guidance documents recognize that community-specific information may be necessary to develop a "more accurate and complete picture" of financial capability.

Additional flexibility is important for assessing affordability conditions in the City, as one of the City's goals in the most recent 2016-2019 Strategic Plan[10] is to improve social equity across the entire community. To this end, the City has identified three neighborhoods in north, central, and east Columbia on which to initially focus their resources to improve equity issues. The IMP affordability evaluation was structured to complement the City's Strategic Plan by characterizing socioeconomic conditions and potential financial impacts both broadly across the City and within sensitive neighborhoods (as measured by Census tracts).



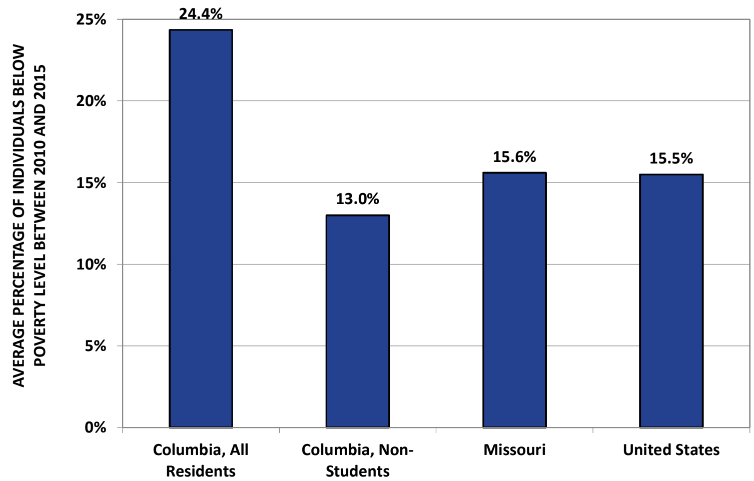
Source: Ysteboe, Taylor. "City begins effort to address social, economic equity issues in three neighborhoods." Columbia Missourian (Columbia, MO). April 13, 2016.

Evaluating impacts on Columbia's strategic planning focus neighborhoods is important to the consideration of overall economic and social equity of IMP investments

An additional complication with assessing affordability in Columbia is that residential customers reside within both the City limits and portions of the Boone County Regional Sewer District (BCRSD) service area outside of the City boundary. The City and BCRSD operate under multiple agreements whereby the City accepts wastewater flows from some BCRSD facilities in order to provide regional treatment services. The City understands that future Sewer Utility rate increases will impact both City and BCRSD ratepayers. However, a focused analysis of potential impacts to BCRSD customers was not conducted because sufficiently detailed socioeconomic data specific to those users were not readily available.

[10] City of Columbia, Missouri. 2015. Strategic Plan 2016-2019. https://www.como.gov/wp-content/uploads/2016-2019-Strategic-Plan.pdf

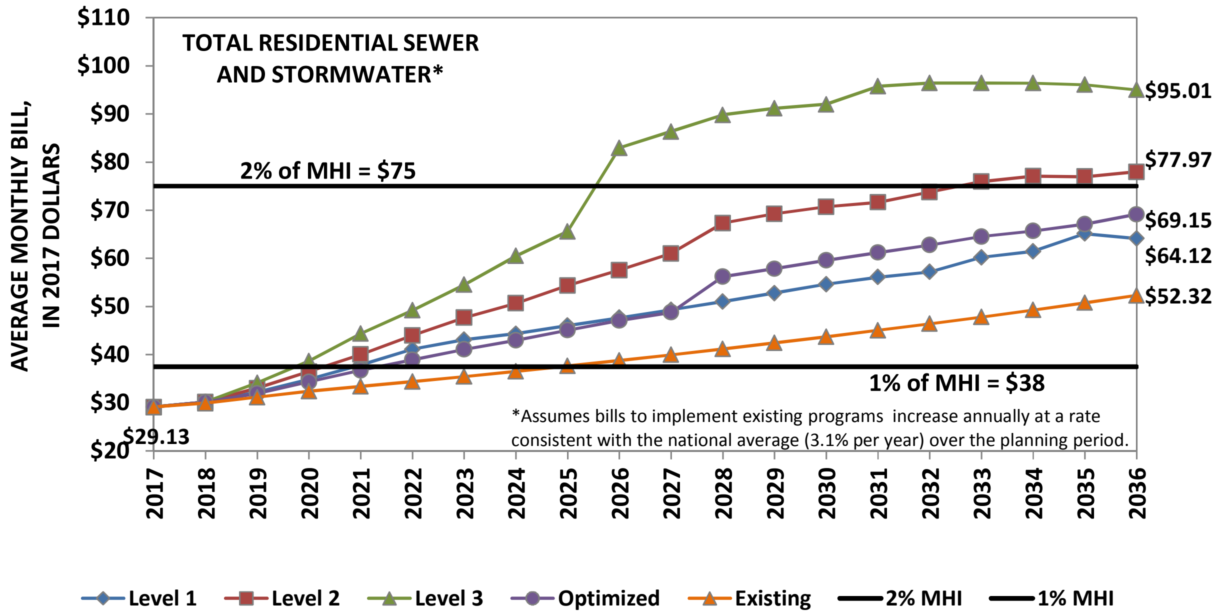
In the analysis of City-wide socioeconomic conditions, the Project Team found that resident college students influence results of important socioeconomic metrics that are traditionally used to characterize communities. For example, approximately 24% of individuals in Columbia are below the poverty level. However, that estimate is influenced by the resident college student population because traditional poverty level measures exclude individuals who live in dormitories but include students living in off-campus housing within the City limits. These students generally report low incomes and contribute to higher poverty rate estimates. After removing students from the population, the individual poverty level in Columbia falls to approximately 13%, which is comparable to levels in Missouri and the United States. In Columbia, resident students also impact estimates of population (driving it higher) and median household income (driving it lower). While the student population is an important segment of the City's customer base, evaluation of socioeconomic metrics of the City's permanent population is a key consideration for the IMP.



While Columbia's overall population indicates significant poverty, the City's permanent population is comparable to the State and National averages

When metrics are assessed for the City's permanent population, overall socioeconomic conditions in the City are generally strong. However, there are disadvantaged segments of the community which warrant additional consideration. To identify those disadvantaged areas, the Project Team evaluated economic stress indicators related to median household income (MHI), median family income (MFI), poverty rates, occupancy rates, homeowner housing costs, renter housing costs, supplemental nutrition assistance program participation rates, and health insurance coverage rates across the 25 census tracts in the City. The analysis indicated that four tracts, primarily located in central Columbia, exceeded stress thresholds for at least 80% of the metrics reviewed and exhibited a strong potential for economic stress.

The qualitative review of socioeconomic stress was coupled with a quantitative assessment of future billing impacts across census tracts to characterize potential affordability issues associated with implementing the Optimized level of funding. Future bills were calculated by the City using existing stormwater and wastewater rate models to forecast future residential user rates and bills based on projected 20-year cash flows for the IMP alternatives. Rate structures were maintained at current base and volume charge ratios for rate and bill forecasting.



The Optimized IMP funding level supports moderate bill increases and maintains community-wide affordability

Under the Optimized funding level, the average community-wide combined stormwater and sewer bill would increase from approximately $29 dollars per month in 2017 to $69 dollars per month in 2036 (in 2017 dollars). Although it is an imperfect indicator, EPA generally considers 1% to 2% of MHI as the limit of affordability for municipal sewer and stormwater ratepayers. Under the Optimized funding scenario, community-wide average bills remain below 2% of MHI during the 20-year planning period. Some residents in the central neighborhood of Columbia may face some affordability impacts, but average bills in that area will not approach the potentially unaffordable level of 2% MHI until 2028 (see Figure 9 of Attachment O). Therefore, the affordability and socioeconomic evaluation suggests that the Optimized funding level will be affordable over the first 10 years of IMP implementation.

The Optimized funding level is preferred because it provides the most overall value to the community, maintains community-wide monthly bills within EPA's traditional 1-2% MHI threshold bounds for affordability, and supports moderate bill increases throughout the planning period. Because the forecasted billing impacts were based on planning level cost estimates, they will likely change as the City gathers additional information and innovates to find cost-effective solutions during IMP implementation. Additionally, changes in regulatory requirements, program needs, or socioeconomic conditions across the City may also influence future affordability projections. Therefore, the City understands that it will be important to refine projected sewer and stormwater program needs, costs, and bill impact evaluations every 5 to 10 years.

5.4 Optimized IMP Suite of Alternatives

The Optimized suite of alternatives is the preferred program portfolio for the IMP because it provides the greatest value to the community and can be implemented affordably. The Optimized portfolio includes a combination of Level 1 funding for most wastewater treatment and collection system project categories and Level 2 funding for stormwater projects. The higher level of stormwater projects is consistent with the results of the existing system performance evaluation (**Section 3**) which highlighted the significance of the City's stormwater system needs relative to the funding currently available.

System	Wastewater Treatment							Wastewater Collection										Stormwater Management						
Project Category	Wet Weather Imp.	Expanded Nitrification	Biological Nutrient Removal	Chemical Disinfection	Constructed Wetlands Impr.	Digester Rehabilitation	Digester Capacity Imp.	Wet Weather Program	Asset Management	System Renewal	System Capacity	Building Backups	Private Common Collectors	System Expansion	Cleaning Program	Pump Station Repair	Annual Improvements	SW Planning	System Assessment	System Renewal	Flood Control	Stream Erosion	Runoff Treatment	MS4 Program
Level 1		✓	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓				✓		✓
Level 2	✓				✓						✓								✓	✓	✓		✓	
Level 3																								

The Optimized suite of alternatives includes the combination of Level 1 and Level 2 funding projects that provide the best value for the community and ratepayers

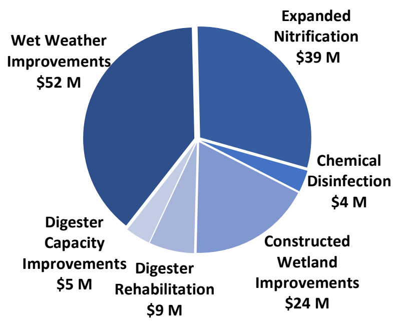
For the wastewater treatment system, the City's largest planned capital expenditure over the 20-year IMP planning period is targeted for addressing wet weather capacity issues at the CRWWTP. Inflow and infiltration into the City's sewer system has caused sewer backups and overflows for decades. Since 2012, significant collection system rehabilitation and I/I reduction projects have been completed and staff have implemented operational changes at the CRWWTP that have significantly reduced sewer overflows along the major trunk sewers, mostly near the treatment plant. Despite these recent improvements, the CRWWTP can further improve management of peak wet weather flows in a manner that effectively limits the number of SSOs within the collection system during very large events. Improvements identified in the Optimized suite of alternatives are intended to reduce SSOs and allow the City to effectively manage peak flows.

Although wet weather improvements are the largest wastewater treatment capital expenditure identified, these improvements will not be implemented until at least 2027 to allow the City to continue ongoing I/I reduction efforts and develop a better understanding of wet weather peak flows and volumes through flow monitoring and modeling. In the near term, necessary projects related to digester rehabilitation and constructed wetlands maintenance are anticipated.

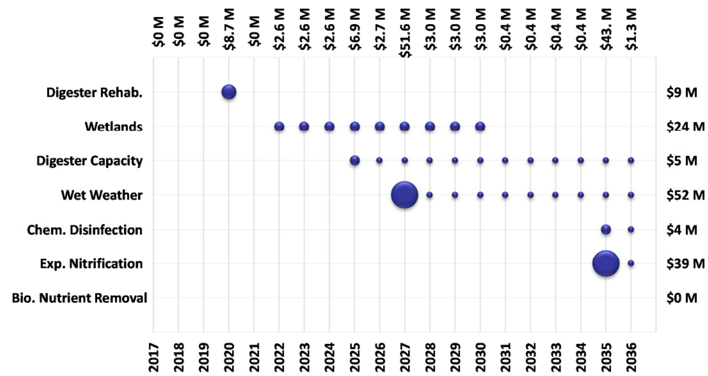
Columbia's Optimized Suite of IMP Alternatives

Refer to Attachments 5, 6, and 7 for Project Descriptions and Detailed Cost Estimates

Wastewater Treatment

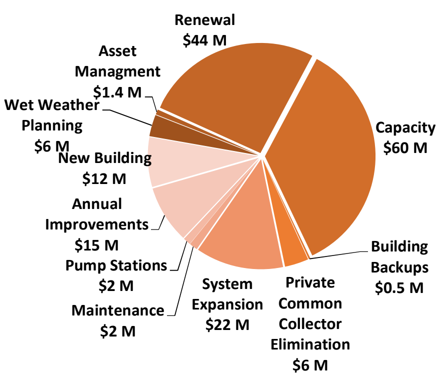


20-Year Total Cost

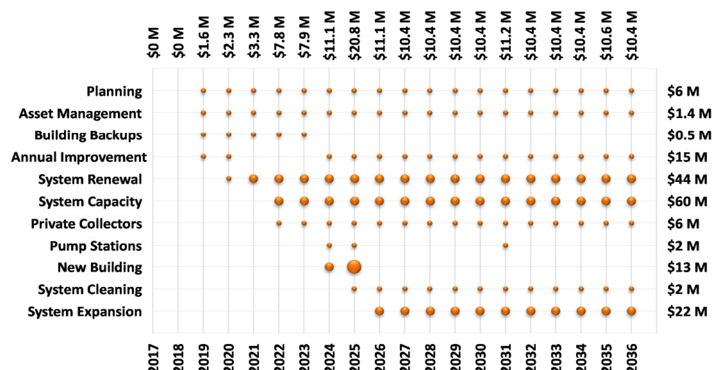


Relative Spending over Time

Wastewater Collection

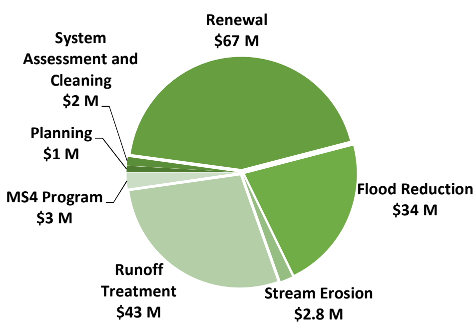


20-Year Total Cost

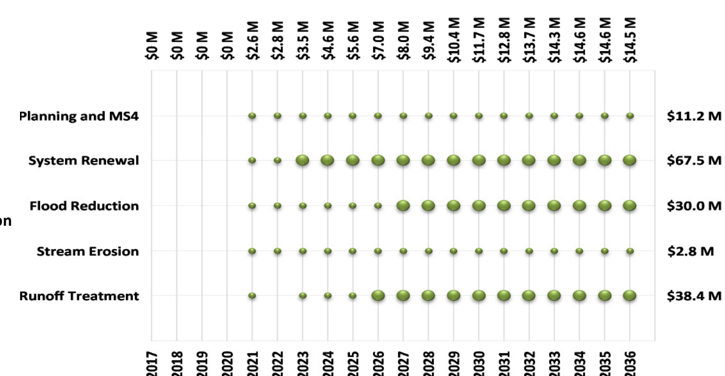


Relative Spending over Time

Stormwater Management



20-Year Total Cost

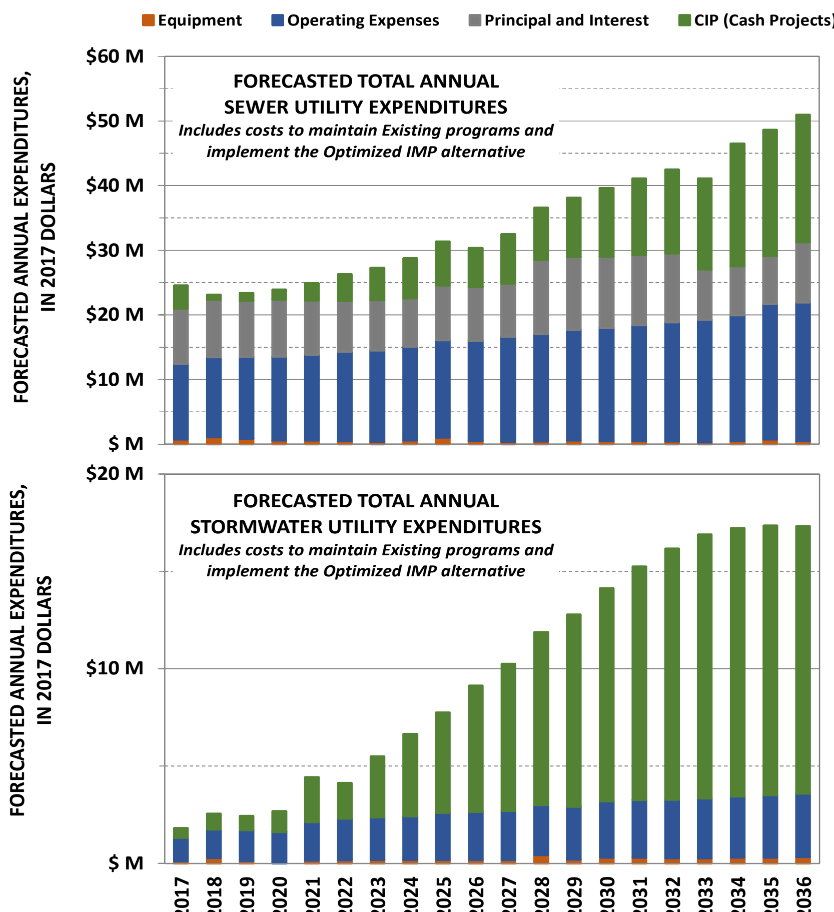


Relative Spending over Time

The optimized IMP funding level includes a suite of projects and program enhancements that balance and prioritize infrastructure needs and community expectations with Clean Water Act goals

In addition to addressing peak flow capacity issues at the CRWWTP, one of the primary goals identified during the two-day IMP visioning workshop described in **Section 2** was to reduce wet weather backups and overflows caused by capacity constraints in the collection system. During early stages of IMP implementation, the Optimized alternative includes funding to improve wet weather planning and implement a backflow prevention program to reduce building backups at individual residences and businesses. The largest anticipated collection system expenditures over the 20-year IMP implementation period are for system renewal and capacity improvements. Anticipated annual costs for these improvements are relatively consistent throughout the period and are intended to address aging infrastructure, reduce public and private I/I, and improve system capacity in critical areas. All of these planning activities, programs, and improvements will address system capacity issues and reduce building backups and SSOs over time.

For stormwater, the 2015 voter-approved rate increase is scheduled to continue through 2020. As a result, the IMP assumes that additional expenditures will not be committed until the City can address potential rate increases in 2021. After 2021, the largest planned expenditures address system renewal needs, flooding issues, and water quality improvements through runoff treatment. Raising the revenue to meet these current and future needs is contingent upon voter approval of stormwater rate increases. In the interim, the City plans to add staff that will help to enhance the stormwater management program and ultimately improve surface water quality across the City. Similar to the sewer system, additional planning resources are needed to improve the longevity and effectiveness of the stormwater system. It has been almost 20 years since comprehensive stormwater management, planning, and modeling tools have been evaluated. Over this period, Columbia has grown and the existing system has



Under the Optimized IMP alternative, forecasted annual expenditures will increase gradually over time

continued to age. Therefore, the Optimized alternative anticipates that resources will be needed during early phases of IMP implementation to conduct stormwater planning that is necessary to maintain the expected level of service.

Annual expenditures to fund the Optimized alternative depend largely on the timing of major capital projects, but must be balanced with respect to financial considerations such as maintaining sufficient debt capacity and cash reserves to ensure the City's programs are planned and administered in a financially responsible manner. Given the anticipated timing and magnitude of projects outlined in the Optimized funding level, the City determined that the annual Sewer Utility budget is projected to increase by approximately $25 million over the 20-year IMP planning period. These projections include the costs for equipment purchases, operations, cash-funded capital projects, and principal and interest payments corresponding to existing and anticipated bond-funded capital projects. For the Storm Water Utility, the annual budget is projected to increase by approximately $15 million over the planning period. As described previously, these Sewer and Storm Water Utility budget increases correspond to a 30% total increase in combined sewer and stormwater bills for the average user in Columbia over the 20-year period.

5.5 5-Year Action Plan to Implement the Optimized Alternative

Element 4 of EPA's Framework specifies that municipalities identify an implementation schedule for their integrated planning projects. The Optimized IMP alternative reflects the City's understanding of infrastructure and regulatory needs and priorities over the next 20-years with respect to the information currently available. As discussed in **Sections 3** and **5.1**, a number of data gaps and uncertainties exist that precluded the development or analysis of specific projects, costs, or implementation dates for many of the program elements evaluated for the IMP. In addition, judicial interpretation of the Missouri Constitution stipulates that municipal stormwater rates must be approved by a majority vote. Bond financing of wastewater capital projects must also be approved through a local election. Therefore, the forecasted timing and cost of wastewater and stormwater program improvements included in the Optimized alternative are planning level estimates that must be more accurately characterized, and in some cases affirmed, by residents before the City can commit to implementation.

To refine the estimates and implement early actions, the City will pursue a 5-Year IMP Action Plan focused on collecting critical data needed to more precisely forecast future needs while continuing to implement currently-identified Capital Improvement Program[11] projects and necessary operation and maintenance activities. The City will pursue these actions to the extent possible but acknowledge that weather, funding, staff availability, and other resource constraints or unanticipated needs may impede complete implementation of the plan. After five years, the City will use the new information to revise IMP projections with respect to evolving regulatory requirements, program needs, and socioeconomic conditions across the City. This implementation approach satisfies Element 6 of EPA's Framework, which requires that municipalities include a process for reevaluating projects and schedules based on changing circumstances to improve overall effectiveness of the plan.

[11] https://www.como.gov/finance/wp-content/uploads/sites/21/2017/10/FY-2018-CIP.pdf

The City's 5-Year IMP Action Plan addresses a range of wastewater and stormwater program needs that were identified during the IMP planning process. Several high priority, early actions will be implemented in the near term to directly and expeditiously reduce significant public health risks, improve water quality, or enhance customer service. These early actions include the following:

- **Wet Weather Improvements (Wastewater Treatment) and Planning (Wastewater Collection) –** As discussed in the previous section, wet weather capacity limitations at the CRWWTP and I/I issues within the collection system currently contribute to sewer backups and overflows in the City. In recent years, City staff have reduced sewer overflows along major trunk sewers through a combination of collection system rehabilitation and I/I reduction projects and operational changes at the CRWWTP. However, additional improvements are needed to more effectively manage peak wet weather flows and the City's existing hydraulic model is not sufficiently accurate to develop long-term capacity improvement alternatives with a high degree of confidence.

  Over the next five years, the City will conduct flow monitoring and develop a comprehensive hydraulic model to yield a better understanding of the collection system. This model will allow the City to better evaluate the benefits and costs of necessary system improvements. In the interim, the City plans to repurpose an existing sludge storage lagoon to provide excess flow storage at the CRWWTP. When combined with the existing peak flow lagoon, this interim improvement will increase wet weather storage capacity to more than13 million gallons.

- **Digester Rehabilitation (Wastewater Treatment) –** Digester rehabilitation must be completed during the first five years to address aging infrastructure and ensure sound operation of the existing CRWWTP. The City is targeting completion of the planned rehabilitation project by 2021.

- **System Renewal (Wastewater Collection) –** The City owns and operates over 715 miles of gravity sewer lines and forcemains. As this existing infrastructure ages and deteriorates, the probability for the occurrence and frequency of overflows and backups in the system increases. Proactive condition assessment and renewal efforts will allow the City to address aging infrastructure through cost-effective, trenchless rehabilitation techniques that minimize disruption to the public. These renewal activities also address a portion of the infiltration entering the system from public sources, which may reduce backups and SSOs. In addition, these improvements mitigate potential exfiltration from the sewer system through broken pipes that could adversely affect water quality. The City currently renews approximatey 0.8% of the existing system annually. Current funding ($2.7 million per year) for renewal work is provided through a 2013 bond issue that extends through 2019. A key area of focus in the City's 5-Year IMP Action Plan is to secure a dedicated, consistent long-term source of funding after 2019 so that the City can continue these renewal efforts uninterrupted.

- **Private Common Collector Elimination (PCCE) (Wastewater Collection) –** Private common collectors (PCC) are privately-owned collection systems that serve multiple homes or businesses. PCCs typically consist of small diameter pipes that have generally not been maintained by the property owners since installation. As these are privately owned collection systems, the City does not have access to maintain or repair these lines. These aging PCCs are prone to blockage or failure resulting in significant public health and water quality risk. Failing PCCs may cause building backups, exfiltrate sewage that exposes the public to pathogens, and exacerbate I/I issues that ultimately contribute to overflows to local water bodies. The City has been working to eliminate PCCs, but funding for these efforts is currently provided through a 2013 bond issue that extends through 2019. A key area of focus in the City's 5-Year IMP Action Plan is to secure a dedicated, consistent long-term source of funding after 2019 so that the City can continue these PCC elimination efforts uninterrupted.

- **Building Backup Reduction (Wastewater Collection) –** Sewage backups into buildings pose significant public health risks. Backups may be due to poor plumbing practices and/or condition, building floor elevations that were constructed too low relative to the sanitary sewer elevation, inadequate capacity in the sewer system, and private I/I sources connected to the service lateral. Many building backups cannot be cost effectively addressed through capacity improvements to the public sewer system. To address this issue, the City recently approved a cost reimbursement program for the installation of low pressure sewers, installation of backflow prevention devices, or the removal of plumbing fixtures on private property (Columbia, MO – Code of Ordinances, Chapter 22, Article II, Section 22-254). Over the next five years, the City will conduct community outreach to build awareness and increase participation in this new program.

- **System Capacity Enhancements and Private I/I Reduction (Wastewater Collection) –** Ultimately, the scope of the program and level of funding needed for system capacity enhancements will be determined based on the wet weather program management and planning activities discussed above. However, capital improvements needed to meet the City's desired level of wet weather service will likely include a combination of capacity improvement projects and I/I reduction efforts. Public I/I reduction is primarily addressed through system renewal efforts. The cost-effectiveness of private I/I control is highly dependent on the source and location. Once the system hydraulic model is developed, the City will evaluate private I/I costs compared to system capacity improvements to determine the most cost-effective strategy to address wet weather challenges.

  Until that time, the City will focus on conducting community outreach to build awareness and increase participation for its recently revised I/I reduction cost reimbursement program. This program reimburses property owners for activities that reduce the input of groundwater, stormwater, or other unpolluted water into the sanitary sewer system. The program was recently updated to more closely align with the building backup cost reimbursement program. The City expects that these revisions will increase I/I reduction efforts by allowing for simpler navigation of the existing program and additional participation by property owners.

- **Municipal Separate Storm Sewer System Program Enhancements (Stormwater Management) –** The City, County, and University of Missouri are co-permittees under a Phase II municipal separarate storm sewer system (MS4) permit issued by MDNR. The three entities are collectively responsible for compliance with their MS4 permit, which includes provisions for developing and implementing a stormwater management program to reduce pollutant discharges to the maximum extent practicable. The MS4 programs implement six minimum control measures (MCM): 1) Public Education and Outreach, 2) Public Involvement and Participation, 3) Illicit Discharge Detection and Elimination, 4) Construction Site Stormwater Runoff Control, 5) Post-Construction Stormwater Management, and 6) Pollution Prevention and Good Housekeeping for Municipal Operations. The City's ability to fulfill its commitments to the other co-permittees and maintain compliance with the requirements of the MS4 permit is an important consideration for the IMP.

  Over the next five years, the City plans to increase stormwater management program activities under MCMs 1, 3, and 4 to enhance water quality protections. Specifically, the City will increase education and outreach activites to build public awareness for the stormwater program and positively influence individual behaviors (MCM 1); improve illicit discharge detection and elimination activities to reduce the direct contribution of bacteria, nutrients, and other pollutants to City streams (MCM 3); and update erosion and sediment control guidelines to reduce sediment runoff from urban areas and construction sites (MCM 4).

  The City will also continue participation in the Hinkson Creek CAM process. As mentioned previously, the CAM process and underlying agreement was developed in response to the USEPA TMDL developed for Hinkson Creek in 2011. Under the agreement, the MS4 partners agreed to work collaboratively to improve water quality in Hinkson Creek using a science-based approach. The CAM process is guided by three stakeholder groups that identify scientific needs, implement management actions, and measure progress towards attaining water quality goals. The City has been actively involved in these stakeholder groups since April 2012, and will continue to work with the MS4 partners to further CAM goals.

Columbia 5-Year IMP Action Plan[1]			
Program or Project[2]	**Goal**	**Anticipated Actions**	**Targeted Community Benefits[3]**
Wastewater Treatment			
Wet Weather Improvements*	Implement early measures to enhance peak flow capacity at CRWWTP.	• Modify existing CRWWTP structures to provide additional wet weather flow storage.	• Protect public health and safety. • Improve quality of life. • Provide sustainable services for the future. • Improve water quality. • Regulatory compliance.
Digester Rehabilitation*	Rehabilitate aging biosolids digestion facilities.	• Target design completion by 2019. • Target construction completion by 2021.	• Provide sustainable services for the future.
Constructed Wetlands Maintenance	Initiate constructed wetlands maintenance efforts to improve treatment efficiency.	• Develop plan and detailed cost estimates for implementing improvement actions.	• Provide sustainable services for the future.
Wastewater Collection			
System Renewal*	Continue system renewal at current rates with appropriation of dedicated funding to provide effective wastewater collection.	• Rehabilitate up to 1% of collection system structures per year, depending upon contractor availability and pricing. • Secure dedicated annual funding for continuted renewal. Current bond funding runs out in 2019.	• Protect public health and safety. • Improve quality of life. • Provide sustainable services for the future. • Improve water quality.
Private Common Collector Elimination (PCCE)*	Implement identified PCCE projects in the CIP with appropriation of dedicated funding to reduce illicit sewage discharges.	• Continue Private Common Collector elimination, depending on ability to gain easements, as well as contractor availability and pricing. • Secure dedicated funding. Current bond funding runs out in 2019.	• Protect public health and safety. • Improve quality of life. • Provide sustainable services for the future. • Improve water quality.
Reduce Building Backups*	Implement backflow prevention program to reduce building backups.	• Obtain Council approval for backflow prevention program with allocation of $100,000 per year for 5 years. • Implement community outreach to build awareness of backflow prevention program.	• Protect public health and safety. • Improve quality of life. • Provide sustainable services for the future. • Improve water quality.
System Capacity Enhancements and Private I/I Reduction*	Reevaluate private I/I program to reduce peak wet weather flows.	• Assess benefits and cost-effectiveness of previous and modified private I/I program. • Implement community outreach to build awareness of modified program.	• Protect public health and safety. • Improve quality of life. • Provide sustainable services for the future. • Improve water quality. • Regulatory compliance.
System Expansion	Provide adequate and cost-effective wastewater services to developing areas for watershed protection.	• Fund expansion projects currently identified in the CIP, as needed. • Develop systematic approach for evaluating sewer extensions to better identify sewer mains that should be upsized to convey future capacity.	• Protect quality of life. • Provide sustainable services for the future. • Improve water quality.
Wet Weather Planning*	Develop collection system model and evaluate future system capacity enhancement strategies.	• Conduct comprehensive flow monitoring through 2020 to calibrate collection system model. • Develop model by 2021. • Evaluate system capacity enhancement strategies through 2022.	• Protect public health and safety. • Improve quality of life. • Provide sustainable services for the future. • Improve water quality. • Regulatory compliance.

Columbia 5-Year IMP Action Plan[1]			
Program or Project[2]	**Goal**	**Anticipated Actions**	**Targeted Community Benefits[3]**
System Cleaning	Enhance sewer cleaning program to practicably mitigate overflows and backups due to blockages.	• Develop prioritized cleaning program. • Purchase new jet truck. • Plan for new building for field operations and collections personnel.	• Protect public health and safety. • Improve quality of life. • Provide sustainable services for the future. • Improve water quality.
Stormwater Management			
MS4 Program Enhancements*	Enhance Public Education and Outreach, Illicit Discharge Detection and Elimination, and Construction Site Stormwater Runoff Control to reduce bacteria, sediment, and trash discharges.	• Continue to develop and distribute public education messages as outlined in the Stormwater Management Plan. • Hire technician to support MS4 program with focus on IDDE. • Conduct streamwalks and outfall inspections in all City streams within 5-year action plan period. • Develop map of stormwater outfalls. • Update Erosion and Sediment Control Manual and policies and procedures. • Continue to work with MS4 partners to effectively implement stormwater management program, particularly Minimum Control Measure #4. • Continue to work with MS4 partners to implement CAM program to improve Hinkson Creek water quality.	• Protect public health and safety. • Improve quality of life. • Provide sustainable services for the future. • Improve water quality. • Regulatory compliance.
System Renewal	Implement renewal program to address failing corrugated metal pipe (CMP) and structures beyond physical effective life.	• Initiate renewal activities as resources and funding allow. • Secure additional funding to implement these actions.	• Protect public health and safety. • Improve quality of life. • Provide sustainable services for the future. • Improve water quality.
Condition Assessment	Establish and begin implementing a condition assessment program.	• Begin assessing CMP throughout the City. • Secure additional funding to implement these actions.	• Protect public health and safety. • Provide sustainable services for the future. • Improve water quality.
Flood Reduction	Address known areas of flooding to reduce public health and safety concerns.	• Implement opportunistic flood reduction projects, depending on available funding after emergency and critical system repairs. • Develop stormwater project ranking system.	• Protect public health and safety. • Provide sustainable services for the future. • Improve water quality.
Runoff Treatment	Reduce pollutant runoff in Hinkson Creek tributary watersheds to improve water quality.	• Implement opportunistic runoff treatment projects, depending on available funding. • Develop stormwater project ranking system. • Continue to implement CAM process.	• Protect public health and safety. • Provide sustainable services for the future. • Improve water quality.

Columbia 5-Year IMP Action Plan[1]			
Program or Project[2]	**Goal**	**Anticipated Actions**	**Targeted Community Benefits[3]**
Stream Erosion Control	Stabilize stream channels with excessive channel erosion to reduce sediment discharges.	• Identify and implement opportunistic stream erosion control projects, depending on available funding after emergency and critical system repairs. • Develop stormwater project ranking system. • Continue to implement CAM process.	• Protect public health and safety. • Provide sustainable services for the future. • Improve water quality.
Planning and Program Support	Develop stormwater master plan and enhance data management processes.	• Initiate master planning and data management efforts. • Secure additional funding to implement these actions.	• Protect public health and safety. • Provide sustainable services for the future. • Improve water quality.
Activities to Measure Water Quality Improvements[4]			
Water Quality Monitoring	Implement water quality monitoring program to help define baseline conditions and track future improvements.	• Develop water quality monitoring plan within first 5 years and implement when additional funding is secured.	• Evaluate IMP effectiveness. • Provide technical basis for future IMP modifications.
Hinkson Creek Flow Gage	Collect continuous Hinkson Creek stream flow data.	• Continue annual funding for USGS flow gage operation.	• Evaluate IMP effectiveness. • Provide technical basis for future IMP modifications.

Note 1 - Goals and actions identified in this 5-Year IMP Action Plan reflect the City's understanding of infrastructure and regulatory needs and priorities with respect to the information currently available. The City will implement these actions to the extent possible but acknowledge that weather, staff availability, Council approval and other resource constraints or unanticipated needs may impede complete implementation of the Action Plan or require that it be modified. Further, the City notes that many of the activities outlined in this Action Plan assume that sufficient additional funding will be made available through sewer rate increases, bond financing that must be approved through a local election, and stormwater rate increases that must be approved by a majority vote. If sufficient additional funding does not become available, the 5-Year IMP Action Plan will be modified to reflect available funding and resources.

Note 2 - High priority program and project needs were identified by City staff and are denoted with an asterisk (*). These represent projects that are intended to directly and expeditiously reduce significant public health risks, improve water quality, or enhance customer service.

Note 3 - Targeted community benefits are presented in **Section 4.3** and explained in greater detail in **Attachments J** and **N**.

Note 4 - Element 5 of EPA's Framework requires that municipalities outline activities that will be used to measure IMP effectiveness. Activities listed here will be used to measure water quality improvements that occur over time. Additional program management and Utility service perfomance measures are discussed in **Section 6**.

Section 6. Measuring IMP Success

Element 5 of EPA's Framework calls for municipalities to outline the performance measures, monitoring data, or milestones that will be used to measure progress as integrated plans are implemented. The City intends to measure both the environmental and programmatic improvements that result from implementing the IMP. These are discussed below.

Measuring Water Quality Improvements

The ultimate goal of EPA's integrated planning process is to provide municipalities with a framework that can be used to affordably meet human health and water quality protections required by the CWA. As presented in the 5-Year Action Plan, the City will measure progress towards meeting these regulatory requirements by developing a water quality monitoring program for City streams and continuing to fund the existing Hinkson Creek flow gage. These efforts will allow the City to track water quality improvements over time and adjust future IMP activities, if necessary.

Measuring Program Efficacy and Service Performance

Program efficacy is generally measured through an evaluation of level of service (LOS) goals. LOS goals are typically qualitative goals used by utilities to guide sewer and stormwater operations. Progress towards meeting LOS goals are generally tracked through a series of quantitative key performance indicators (KPI) that are used to evaluate a utility's success in meeting strategic goals, quantify the benefits of continuous improvement initiatives, and to measure performance in managing infrastructure.

Through IMP development, the City and Project Team reviewed existing LOS goals and KPIs for the Sewer (**Attachment K**) and Storm Water (**Attachment M**) Utilities to identify performance measures that could be used to measure success of the IMP over time. For the Sewer Utility, the City has focused on taking actions to address dry weather operations, wet weather operations, and system renewal. For the Storm Water Utility, the City is interested in providing public safety, improving environmental integrity, renewing and maintaining the conveyance system, and adequately funding and staffing the Utility.

Although the City has goals for each Utility, IMP planning efforts highlighted the fact that the City has numerous information gaps that must be filled in order to develop a more complete understanding of the systems, create formal goals, and reliably track KPIs. For example, the City needs to develop an accurate hydraulic model to understand the costs and benefits of establishing a specific wastewater collection system design storm prior to defining the City's LOS goal for wet weather conveyance. With respect to the Storm Water Utility, improved management of the existing data collection, tracking, and maintenance procedures will improve future stormwater system planning, maintenance, and performance.

The City will refine LOS goals and KPIs over time as the IMP is implemented. In the interim, IMP success will be measured using milestones and actions outlined in the 5-year IMP Action Plan. At the end of the first five year period, the City will evaluate progress to determine if goals were achieved and make necessary changes and adjustments during future phases to ensure continuing progress towards satisfying infrastructure demands and meeting CWA obligations.

Section 7. Alignment with Mayor's Task Force on Infrastructure

As discussed in **Section 1**, the City has proactively been working to identify and prioritize the City's infrastructure needs. In August 2015, the City formed the Mayor's Task Force on Infrastructure (MTFI) to review the City's infrastructure needs, including those in the sewer and stormwater systems. To maintain consistency between infrastructure planning activities being conducted in the City, the Project Team reviewed the functional stormwater and sewer recommendations outlined by the MTFI in their 2016 Final Report to evaluate alignment with recommendations developed independently from the IMP process. Financial and policy recommendations developed by the MTFI were not reviewed as these items are outside the scope of the IMP.

MTFI Functional Storm Water Utility Recommendations

The MTFI Final Report included the following four functional recommendations for the stormwater system:

1. The City should expand its internal and cooperative mapping capacity with MU and Boone County, cataloguing equipment information, engaging water runoff tools, and continued use of Light Detection and Ranging (LIDAR).

   Currently, scheduled data exchanges occur on an regular basis with the members of the GIS consortium. This recommendation aligns with IMP recommendations to increase funding for program support, which would include enhancing data management and geographical information system (GIS) mapping processes. The Optimized alternative assumes approximately $1 million in funding for this program element over the 20-year planning period. Additional discussion of this recommendation is included in **Section 3.1** of **Attachment M**.

2. The City should coordinate with MU and Boone County to install an automated rain gauge system to better track precipitation within the MS4 permit area.

   An automated rain gauge system would be useful for characterizing rainfall patterns and runoff in the service area. However, it would take many years of data for any improvements in design criteria to be realized and would provide limited immediate operational improvements. Given the magnitude of funding allocated to the address immediate stormwater system needs in the Optimized alternative ($224 million), installing and maintaining a rain gauge system is considered a low priority due to fisical constraints. Therefore, this system is not included within the IMP recommendations. As the City implements the IMP over time, the addition of a rain gauge system should be reevaluated. The City should also investigate the utility of alternative methods, such as gauge adjusted radar, which may provide a more efficient tool for characterizing rainfall across the City.

The IMP does recommend that the City reevaluate key stormwater design standards, such as the assumed temporal storm distributions (See **Section 3.2** of **Attachment H**), to help address runoff control and stream channel stability.

3. The City should model the public stormwater system hydraulics to identify system deficiencies to assess future impacts of development and troubleshoot existing capacity.

   This MTFI recommendation aligns with IMP recommendations to increase funding for master planning and conveyance system modeling support. The Optimized alternative assumes approximately $1 million in funding for this program element over the 20-year planning period. Additional discussion of this recommendation is included in **Section 3.1** of **Attachment M**.

4. The City should adopt an objective grading system to prioritize stormwater capital improvement projects ensure a consistent and objective evaluation process for selecting projects.

   This MTFI recommendation aligns with IMP recommendations to increase funding for master planning, modeling, and program support. These efforts will enhance project planning, prioritization, and identification of improvement locations to more fully meet conveyance system assessment goals. They will also help to refine future funding needs and identify a long term improvement plan to address the conveyance issues present within the system. The City has already started developing a weighted scoring system to prioritize potential projects. The Optimized alternative assumes approximately $1 million in funding for continued development of a stormwater master plan. Additional discussion of this recommendation is included in **Section 3.1** of **Attachment M**.

MTFI Functional Sewer Utility Recommendations

The MTFI final report included seven functional recommendations for the sewer system:

1. The City should create a comprehensive wastewater collection system model, including physical and hydraulic attributes to better analyze changes to the system.

   This MTFI recommendation aligns with IMP recommendations to increase funding for wet weather program planning and asset management support. This will be one of the first objectives to be implemented. The Optimized alternative assumes $6 million in funding for this program element, which is included within the 5-Year IMP Action Plan. Additional discussion of this recommendation is included in **Section 3.1 and 3.2** of **Attachment K**.

2. The City should define a residential sewer user as "the owner or occupant of a dwelling unit that is connected directly or indirectly to the city's sanitary sewer system".

   This MTFI recommendation is a policy decision that falls outside the scope of the IMP.

3. The City should rehabilitate or replace a minimum of one percent of the sewer collection system annually.

This MTFI recommendation generally aligns with IMP recommendations for system renewal. The Optimized alternative assumes $44 million in funding for this program element. Additional discussion of this recommendation is included in **Section 3.3** of **Attachment K**. Note that the exact percentage of the system renewed each year is anticipated to vary based on the size of the infrastructure being addressed and the corresponding types of renewal work required. On average, between 0.8% and 1% of the system will likely be renewed on an annual basis.

4. The City should pursue programs that place greater responsibility on property owners to identify and eliminate private sources of inflow and infiltration.

The IMP Project Team agrees with this MTFI recommendation. However, the recommendation contradicts the MTFI recommendation that the City should assume greater responsibility for the condition of private service lateral infrastructure (addressed in item 5, below). The IMP project team recommends that the City further evaluate cost-effective means of reducing private I/I during wet weather program development. The City recently revised Section 22-217.3 of the City code to update I/I reduction program requirements to more closely align with the cost reimbursement program for the installation of low pressure sewers, backflow prevention devices, or removal of plumbing fixtures. The City expects that these revisions will increase I/I reduction efforts by allowing for simpler navigation of the existing program and additional participation by property owners. The City will implement outreach to build awareness of the programs.

5. The City should assume responsibility for all connection points within the public sewer as well as responsibility for any portion of a private sewer service lateral located within a public right-of-way or within a dedicated sewer easement.

The IMP does not include this recommendation. There are approximately 50,000 private service lateral connections to the City's collection system. Assuming responsibility for all service lateral connection points and the portion of all private service laterals located within a public right-of-way or sewer easement would substantially increase the amount of sewer infrastructure managed by the City. A preliminary analysis based on typical right-of-way and easement widths estimated that this would add over 200 miles of sanitary sewer that would be managed by the City (note that mapping of the locations of these private service laterals is not available and this mileage could be greater than estimated).

Unlike the City's public sewers, most private service laterals have not been regularly cleaned, inspected, or repaired. If the City were to assume responsibility for this privately owned infrastructure, the City would need to regularly maintain, inspect, and rehabilitate these service laterals. Service laterals are typically small diameter pipes that often include many horizontal and vertical bends; this necessitates the use of special equipment to maintain and inspect these pipes. Additionally, many laterals have limited accessibility and in their existing state would not be accessible except through interior building plumbing (as opposed to public sewers which are accessed through manholes for typical maintenance and inspection activities). Installation of cleanouts is anticipated to be required on the majority of lines in order to enable the City to access them. Cleanout installation alone for 50,000 service laterals would take more than 40 years based on completing five installations per day.

The inspection, maintenance, and rehabilitation of these private service laterals would represent a major ongoing expense for the City. A preliminary estimate of the 20-year cost of ownership to the City for this privately owned infrastructure is approximately $237 million.

In addition to the economic cost of ownership, there are several other challenges involved with assuming ownership of this infrastructure that are not readily quantifiable. Other identified considerations involved with assuming ownership of sewer laterals are listed below:

- The full regulatory impacts of assuming ownership of the private service laterals is unclear, but it would likely increase the City's risk in this area. It in anticipated this would significantly increase the number of backups the City is considered responsible for by regulatory entities and could potentially increase the risk of regulatory enforcement.
- Whenever a building backup occurs due to a blockage in a private service lateral, an investigation would need to be completed in order to determine if it was caused by a blockage in the city-owned portion of the lateral, or in the privately owned portion (outside the public right-of-way or easement).
- The City would be responsible for providing location information for these service laterals whenever utility locates are called in prior to digging. The City would need to develop detailed mapping of the location of these laterals to facilitate locates. The City would also need to expend additional resources (either additional staff or increased contract costs) on an ongoing basis to adminster the location of these service laterals. Note that service laterals are typically shallower than the public sewer and are more susceptible to being damaged during construction and utility installation efforts.
- Service lateral rehabilitation costs presented in the table at the end of this section are based on estimated contracted renewal costs. Assuming ownership of this infrastructure may also necessitate the City adding additional repair crews and equipment to execute emergency repairs of structurally failed service laterals.

Because the City is focused on securing long-term funding for maintenance and replacement/renewal of the existing public sewer system, the high financial cost to the City to take over ownership of these private systems and other challenges associated with assuming ownership of these private systems the Project Team suggests that the City not adopt this MTFI recommendation.

6. The City should continue investigating and rehabilitating the sewers in the "I&I Pilot Study Area".

The I&I Pilot Study Area was an area identified for a pilot study in 2008[12]. This area was expanded to become Flat Branch Basin D. Post flow monitoring of this area was conducted and a report was provided to Council in September 2014 that demonstrated a 19% reduction in peak flow and a 48% reduction in total volume. Since that time, more of the system in the area has been rehabilitated. At this time, additional funding for this area should be limited to providing assistance for backflow prevention and private I/I reduction. A very large amount of funding could be spent in this area with no further significant reduction in the amount of I/I entering the City's system. The financial resources should more appropriately be spent following the ith IMP recommendations for system renewal and public I/I (see **Section 3.3** of **Attachment K**) and the system capacity enhancement and private I/I (see **Section 3.4** of **Attachment K**). The Optimized alternative assumes approximately $44 million and $60 million in funding for these program elements over the 20-year planning period, respectively.

7. The City should implement a sanitary sewer backflow prevention program that would provide financial assistance to qualifying property owners.

This MTFI recommendation aligns with IMP recommendations for building backup alleviation. The Optimized alternative assumes $500,000 funding for this program element. This program was approved by Council in 2017. Additional discussion of this recommendation is included in **Section 3.5** of **Attachment K**.

[12] https://www.como.gov/utilities/sewer/i-and-i/

Preliminary Estimate of 20-Year Cost of Ownership for all Service Lateral Connection Points and the Portion of Service Laterals Located in the Public Right-of-Way and Easements		
Description	**Unit**	**Value**
Assumptions on Lateral Assets in Right-of-Way		
Total Service Laterals Managed by City	#	50,000
Total Estimated Length of Portion of Laterals Managed by City	LF	1,750,000
	MI	236.7
Service Lateral Maintenance Program (Cleaning)		
Lateral Cleaning Frequency	YR	5
Cleaning Unit Cost	$/LF	1
Cleaning Truck w/ Specialized Equipment	$/EA	250,000
Cleaning Truck Replacement Schedule	YR	10
Install Cleanouts to Access Lateral (Assume 75%)	EA	$1,800
Cleaning Crew – Operator FTE	$/YR	44,000
Cleaning Crew – Lead Jet Operator	$/YR	52,000
Subtotal – 20-YR Cleaning Cost	**$**	**76,920,000**
Service Lateral Inspection Program (CCTV)		
CCTV Unit Cost	$/LF	1.25
Two CCTV Trucks With Special Equipment to Televise Laterals	$	500,000
CCTV Truck Replacement Schedule	YR	10
Lateral CCTV Frequency	YR	10
CCTV Crew – Operator FTE (2 Operators)	$/YR	88,000
CCTV Crew – CCTV Tech (2 Techs)	$/YR	124,000
Subtotal – 20-YR CCTV Cost	**$**	**9,615,000**
Service Lateral Rehabilitation Program (CCTV)		
Assumed Rehabilitation Percentage	%	50
Rehabilitation Unit Cost (Lateral and Connection)	$/EA	6,000
Subtotal – 20-YR Rehabilitation Cost	**$**	**150,000,000**
Preliminary Estimate - Total 20-YR Cost of Ownership		***$237,000,000***

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Columbia Wastewater and Stormwater IMP

Attachments

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Columbia Wastewater and Stormwater IMP

Attachment A

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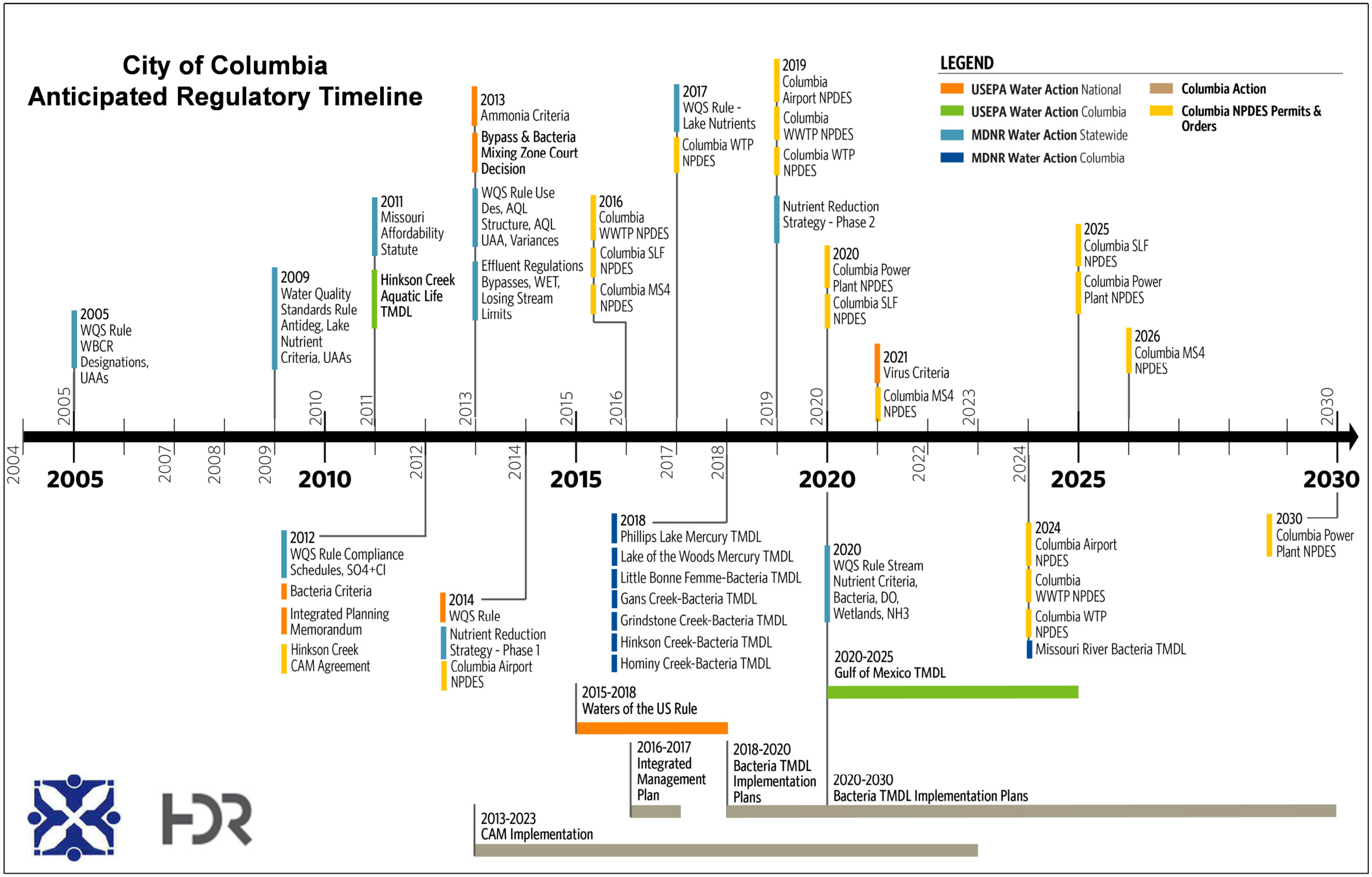
Attachment A
City of Columbia's Anticipated Regulatory Timeline



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Columbia Wastewater and Stormwater IMP

Attachment B

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Memorandum of Understanding
between the
Missouri Department of Natural Resources and the City of Columbia, Missouri
regarding the
Integrated Management Plan for Wastewater and Stormwater

Purpose

The purpose of this Memorandum of Understanding (MOU) between the Missouri Department of Natural Resources ("department") and the City of Columbia, Missouri ("Columbia") (collectively, the "Parties") is to acknowledge and agree upon that Columbia will develop an Integrated Management Plan (IMP) for their wastewater and stormwater system improvements with implementation schedules. The purpose of this MOU is to acknowledge that Columbia is preparing an IMP and that the department will use the plan, upon its completion and agreement, in future regulatory decisions.

Background

On June 5, 2012, the United States Environmental Protection Agency (EPA) published its Integrated Municipal Stormwater and Wastewater Planning Approach Framework[1]. The department's draft Missouri Integrated Plan Framework[2] is available to assist municipalities in meeting their water, wastewater and stormwater obligations under state and federal regulations. The final document will be posted on the department's website in the near future. The stated purpose of EPA's framework is to "*assist municipalities on their critical paths to achieving human health and water quality objectives of the Clean Water Act by identifying efficiencies in implementing requirements that arise from distinct wastewater and stormwater programs, including how to best prioritize capital investments.*"

Over the next several years, Columbia plans to complete improvements to their wastewater and stormwater systems as established in their IMP. The IMP will help prioritize permit and enforcement requirements by taking into consideration the potential harmful effects to human and environmental health as well as the potential future costs to be borne by the residents of Columbia. When appropriate, Columbia agrees to incorporate green infrastructure approaches toward compliance with requirements as part of the IMP.

Implementation

Columbia's IMP will contain all of the components of an integrated plan as written in the final version of the framework published by EPA. Communication with the department is encouraged during this time to ensure all criteria are met during the drafting phase of the plan.

Once the IMP is written and agreed to by the parties, the department will modify schedules of compliance within the Missouri State Operating Permit and/or enforcement orders, where appropriate. Further, as decisions related to schedules will be based on the IMP, Columbia's Missouri State Operating Permit (#MO-0097837), future enforcement orders (if such may be necessary), and their stormwater permit (#MO-136557) will refer back to the plan as justification of schedules for compliance. The schedules agreed to must be consistent with 40 CFR § 122.47.

Agreement

The Parties enter into this MOU to provide Columbia assurance that the department agrees with the intent of Columbia to write an IMP which will include improvement to their wastewater and stormwater systems. The plan shall follow the guidance as written in EPA's Integrated Municipal Stormwater and Wastewater Planning Approach Framework.

Agreement to and compliance with the MOU does not remove any obligations of Columbia to comply with their Missouri Clean Water Law (MCWL) and Clean Water Act (CWA) requirements, nor does it lower existing regulatory or permitting standards, but rather recognizes the flexibilities within the MCWL and CWA for the appropriate scheduling of work.

Entry into Force

The MOU will become effective and enforceable upon signature by the Parties.

Duration and Amendment

The MOU is effective for an initial period of five years and may be renewed or amended by mutual agreement in writing between the Parties.

Termination

Each Party has the right to terminate the MOU by giving six months' notice in writing to the other Party at any time.

Authority

Each Party has full knowledge of and has consented to this MOU, and represents and warrants that each person who signs this MOU on its behalf is duly authorized to execute this MOU on behalf of the respective Party and legally bind the Party represented to this MOU.

Missouri Department of Natural Resources **Water Protection Program**	**City of Columbia, Missouri**
David J. Lamb, Acting Director	**Mike Matthes, City Manager**
2-2-2017 **Date:**	12-29-16 **Date:**

ATTEST:

Sheela Amin, City Clerk
Date: December 29, 2016

APPROVED AS TO FORM:

Nancy Thompson, City Counselor
Date: n/a, 2016

References:

1. Integrated Municipal Stormwater and Wastewater Planning Approach Framework; available from https://www.epa.gov/sites/production/files/2015-10/documents/integrated_planning_framework.pdf
2. Missouri Integrated Planning Framework (draft); available from http://dnr.mo.gov/env/wpp/cwforum/docs/integrated-framework-draft.pdf

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Columbia Wastewater and Stormwater IMP

Attachment C

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Our Columbia Waters
Integrated Management Plan
Wastewater & Stormwater

Columbia Wastewater and Stormwater Integrated Management Plan

Project Framework and Approach

HDR

Geosyntec consultants

Shockey Consulting Services, llc

TREKK

City of Columbia, MO

August 31, 2016

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Introduction

Over the past decade, population growth, aging infrastructure, increasingly complex water quality issues, and challenging economic conditions have strained municipal utility management across the country. This situation has been further complicated by federal and state regulatory structures that focus on enforcing individual Clean Water Act (CWA) requirements on fixed schedules, without full consideration of all obligations that a utility may be facing or whether compliance efforts will result in meaningful improvements in environmental and public health. These siloed regulatory processes limit a community's ability to efficiently manage their utilities because they must continually address new regulatory requirements on a "first come, first served" basis, rather than prioritizing affordable and protective solutions to resolve the most critical environmental and public health issues. These processes also lead communities to become more reactive than proactive.

In 2011, the US Environmental Protection Agency (EPA) recognized that when afforded the flexibility to balance wastewater and stormwater improvements, municipalities can cost-effectively make important environmental improvements aligned with community priorities[1]. To support communities in these efforts, EPA released the *Integrated Municipal Stormwater and Wastewater Planning Approach Framework* in 2012[2]. Integrated planning will assist municipalities in achieving human health and water quality objectives by providing the opportunity to use CWA flexibilities to identify efficiencies in implementing wastewater and stormwater programs. It is important to recognize that integrated planning does not remove or lower obligations to comply with the CWA. It also does not lower or remove existing regulatory or permitting standards. However, integrated planning does recognize that there are flexibilities in the CWA that allow municipalities to appropriately prioritize and schedule work within a community's financial capability.

Integrated Planning Allows the City to Proactively and Affordably Balance and Prioritize Regulatory Issues and Infrastructure Needs

The City of Columbia, Missouri (City) faces a number of past, present, and future regulatory drivers (**Attachment A**) along

[1] Stoner, N. and C. Giles. 2011. Achieving Water Quality through Integrated Municipal Stormwater and Wastewater Plans. October 27, 2011. Washington DC.
[2] Stoner, N. and C. Giles. 2012. Integrated Municipal Stormwater and Wastewater Planning Approach Framework. June 5, 2012. Washington DC.

with service demands that will impact infrastructure decisions and investments for several decades. The City recognizes that the current "trickle down" regulatory process is inefficient and understands that developing an integrated management plan (IMP) to address CWA issues will help the City meet evolving regulatory obligations while continuing to address challenges in operating and maintaining existing infrastructure investments.

In Spring 2016, the City retained HDR Engineering, Inc. (HDR), and their team, which includes Geosyntec Consultants, Inc. (Geosyntec), Shockey Consulting Services, LLC (Shockey), Black and Veatch, Inc. (B&V), and TREKK Design Group, LLC (TREKK), to assist in developing the IMP. The IMP will be based on the EPA guidance referenced above. The goal of the IMP is to develop an adaptable and affordable capital improvement plan that addresses the City's wastewater and stormwater management needs and meets CWA obligations in a prioritized manner.

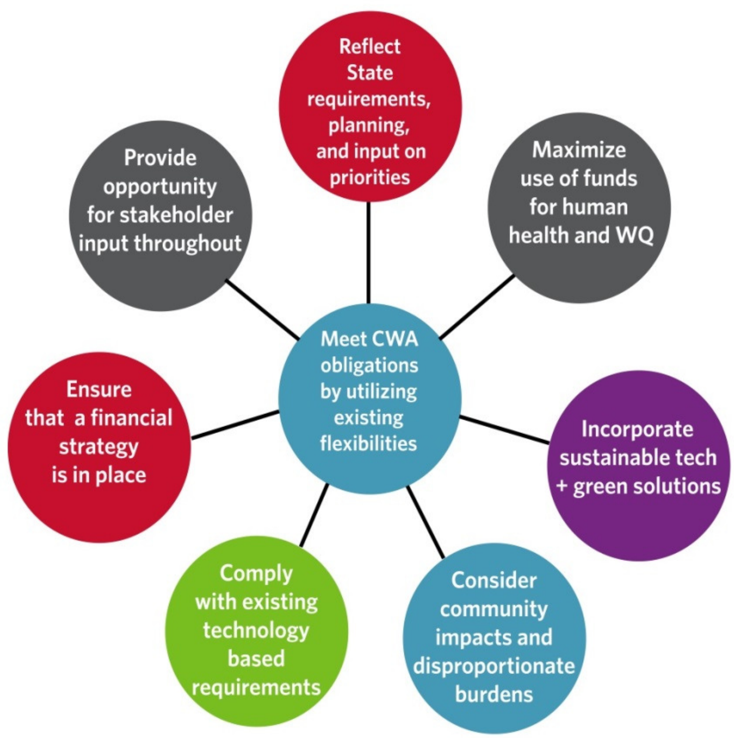
The purpose of this Framework document is to outline the City's anticipated approach for developing the IMP. This Framework will guide IMP project activities and will serve as the foundation for the planning process going forward.

Integrated Planning Principles

In their 2012 *Integrated Municipal Stormwater and Wastewater Planning Approach Framework*, EPA recommended a number of guiding principles that municipalities should consider when developing integrated plans. According to EPA, integrated plans should:

1. Reflect State requirements and planning efforts and incorporate State input on priority setting and other key implementation issues.

2. Provide for meeting water quality standards and other CWA obligations by utilizing existing flexibilities in the CWA and its implementing regulations, policies, and guidance.



EPA's Guiding Principles of Integrated Planning

3. Maximize the effectiveness of funds through analysis of alternatives and the selection and sequencing of actions needed to address human health and water quality-related challenges and non-compliance.

4. Evaluate and incorporate, where appropriate, effective sustainable technologies, approaches and practices, particularly including green infrastructure measures, in integrated plans where they would provide more sustainable solutions for municipal wet-weather control.

5. Evaluate and address community impacts and consider disproportionate burdens resulting from current approaches as well as proposed options.

6. Ensure that existing requirements to comply with technology-based and core requirements are not delayed.

7. Ensure that a financial strategy is in place, including appropriate fee structures.

8. Provide appropriate opportunity for meaningful stakeholder input throughout the development of the plan.

EPA recognizes that municipalities will need to develop integrated plans that are appropriately tailored to the size of the municipality and the scope and complexity of the issues they face. However, the EPA suggests that all integrated plans should generally address the following six elements:

Element 1: A description of the water quality, human health and regulatory issues to be addressed.

Element 2: A description of existing wastewater and stormwater systems under consideration and summary information describing the systems' current performance.

Element 3: A process which opens and maintains channels of communication with relevant community stakeholders in order to give full consideration of the views of others in the planning process and during implementation of the plan.

Element 4: A process for identifying, evaluating, and selecting alternatives and proposing implementation schedules.

Element 5: A process for evaluating the performance of projects identified in a plan.

Element 6: An adaptive management process for making improvements to the plan.

Columbia IMP Project Approach

The City and the IMP Team reviewed EPA integrated planning guidelines and developed a tailored approach that will allow the City to affordably meet CWA requirements while planning for future infrastructure investments. The IMP Project Approach includes six steps toward building an adaptive IMP for CWA compliance and short- and long-term wastewater and stormwater infrastructure plans. Implementation of this logical, stepwise process will satisfy EPA's integrated planning guidance. At the same time, the IMP should support the City's vision to have vital and resilient communities throughout the City.

The City envisions building the IMP in a phased manner to address the most critical existing infrastructure and regulatory drivers first, while allowing adequate time to gather the information needed for thoughtful infrastructure planning. The City believes that this tailored approach will lead to the development of an adaptable IMP that addresses current regulatory drivers, provides investment certainty over the next 5-10 years, accounts for necessary non-regulatory investments prior to taking on investments to deal with future drivers, and defines affordability for the City's ratepayers and financial capability for the wastewater and stormwater utilities.

Columbia IMP Project Approach

Step 1 - Build the Vision

Every successful planning process begins with a well thought out, unified vision. To build a cohesive vision for the IMP, the City hosted a two-day Visioning Workshop in May 2016 to discuss existing and future challenges facing the City, goals and objectives of the IMP, and potential IMP strategies to meet those goals. Workshop participants included representatives from a number of City Departments, including: City Management, Utilities Department, Columbia/Boone County Public Health and Human Services, Finance Department, Sustainability Office, Legal Department, and Community Relations. Representatives from the University of Missouri, Boone County, and the Boone County Regional Sewer District also participated. The City Mayor and Council were also individually interviewed to capture the critical issues and outcomes for the IMP process.

Over the course of the two-day Workshop, the group discussed issues that will impact IMP development, including anticipated state and federal regulatory drivers, affordability concerns, and strategies for accurately characterizing cost impacts on ratepayers, current conditions and future expectations for the City's wastewater and stormwater systems, and potential community outreach approaches and key stakeholder groups that should be included in the process.

Through these discussions, the group broadly characterized the goals, priorities, and challenges that should inform the IMP. These ideas were captured in a vision statement:

Columbia IMP Vision Statement

The stormwater and wastewater Integrated Management Plan is a community-driven, affordable infrastructure plan that enhances human health and safety, water quality, economic vitality, and environmental resources by leveraging existing assets and implementing innovative solutions.

The intent of the vision statement is to clearly and effectively communicate the intent and desired outcomes of the IMP to community stakeholders. To achieve this vision and guide the successful development and implementation of the City's IMP, several key considerations identified during the Workshop must be addressed during the planning process.

- Regulatory uncertainty is one of the largest challenges facing the City. The plan should provide five years of regulatory certainty so that the City can conduct important system condition assessments, develop asset management tools, and undertake other improvements that are necessary to develp an effective, long-term asset management and capital improvement program.

- Financial impacts on all City ratepayers, and specifically disadvantaged communities, must be carefully considered as IMP alternatives are developed or implemented. The project team will prepare a financial capability assessment consistent with EPA's policy[3].

- Integrated planning is a community-driven process. Therefore, stakeholder and community involvement will be critical to developing an effective IMP. As part of the engagement efforts, it will be important that the City obtain input from a wide variety of community stakeholders. Information needs to be developed so that the community can easily understand the known problems and how the proposed projects will address these problems and provide additional benefits.

- The IMP recommendations should focus on identifying projects that have multiple benefits and are technically-feasible, prioritized, funded, and supported by the community. Specifically, the plan will be successful if it provides a means to implement currently planned, critical infrastructure projects over the next five years and sets the City up to successfully plan for and meet long-term environmental and infrastructure goals. In the near term, the IMP should focus on the most critical wastewater and stormwater priorities, which include:

    - Developing and implementing an asset management system to support system renewal efforts, identify performance baselines, measure progress, and assist in communicating infrastructure needs to ratepayers;

[3] Kopocis, K. and C. Giles. 2014. Financial Capability Assessment Framework for Municipal Clean Water Act Requirements. November 24, 2014. Washington DC.

- Addressing wet-weather issues, particularly basement backups, sanitary sewer overflows (SSOs), and areas with persistent inflow and infiltration (I&I) challenges;
- Reducing capacity issues in the existing wastewater treatment and collection systems; and
- Improving stormwater planning, education, outreach, and inter-departmental coordination in an effort to formalize projects needed to address known drivers and justify future funding needs.

Columbia's IMP will provide the City with a Strategic Roadmap for Planning Infrastructure Investments and Clean Water Act Compliance

The vision, goals, and key considerations identified in the Workshop will serve to initially focus project activities as the IMP moves forward, but may be modified based on the results of technical evaluations or community engagement efforts over the course of the project.

Step 2 – Evaluate Existing System Performance

The second step of the City's IMP process is to evaluate the performance and needs of its existing wastewater and stormwater collection and treatment systems. This step directly addresses Element 2 of EPA's IMP framework and forms the basis for developing an asset management program (Element 4) to help facilitate refinement of future IMP phases. As part of this effort, the City and their project team will:

- ***Compile Existing Wastewater and Stormwater Performance Data*** to develop a comprehensive understanding of existing condition, including the location and frequency of SSOs, basement backups, and flooding. Treatment process data will also be gathered to evaluate performance from recent wastewater treatment plant upgrades.

- ***Assess Current Surface Water Quality Conditions*** to identify current and potential future surface water quality priorities in the City. These data will be summarized to facilitate development of water quality improvement strategies.

- ***Characterize Wastewater and Stormwater Utility Performance, Conditions, and Programs*** to understand the effectiveness of existing processes and develop performance baselines that can be used to measure future improvments.

Guided by the IMP Vision Statement developed in Step 1, the project team will use the information collected in Step 2 to prioritize asset needs, identify critical issues or high priority areas, and outline important data needs that should be collected to address these issues.

Step 3 – Develop a Community Outreach Program

As the City noted during the Visioning Workshop, effective community outreach will be a critical component of the IMP process. Element 3 of EPA's 2012 Integrated Municipal Stormwater and Wastewater Planning Approach Framework suggests: *A process which opens and maintains channels of communication with relevant community stakeholders in order to give full consideration of the views of others in the planning process and during implementation of the plan.*

During the Visioning Workshop, attendees discussed potential alternatives for outreach activities such as conducting focus groups with informed stakeholders, holding outreach events for the general public, meeting with individual community leaders, and using websites and social media. The group also discussed the importance of coordinating community engagement efforts with other existing committees, such as the Columbia Water and Light Integrated Water Resource Plan (IWRP) committee. Workshop attendees identified a number of environmental, social, and business-oriented groups that could be included in the IMP process.

Potential Community Groups to Include in IMP Process

- Missouri Department of Conservation
- Audubon Society
- Missouri River Relief
- Sierra Club
- Hinkson Collaborative Adaptive Management Stakeholders
- PedNet
- Downtown Columbia Leadership Council
- Columbia Chamber of Commerce
- Lawn Care Companies
- Local Developers and Construction Companies
- Local Industry
- Central Missouri Community Action Center
- Churches
- Central Missouri Opportunity Council
- University of Missouri
- League of Women Voters of Columbia-Boone County
- Neighborhood Associations and Home Owners

The project team will develop a Community Outreach Plan to better define the process to involve the community in IMP decision-making. The approach will focus on bringing people from the community together, educating them about the various issues, and gathering input in a structured, inclusive, and transparent process.

Feedback and information gathered from the engagement activities will be used to refine the goals, priorities, and vision developed during Step 1. Once the draft IMP is developed, it will be presented to stakeholders and community leaders to gain feedback. Input received from the community will be incorporated into the final IMP, as appropriate, before being presented to the City Council.

Step 4 – Evaluate Alternative Solutions

Based on the IMP Vision and existing system performance assessment, the project team will identify and assess solutions for system and water quality improvements. This is by far the most complex step in the planning process, as the preference is to identify alternatives that could be implemented affordably and provide a net environmental benefit. As part of this effort, the City and their project team will:

- ***Establish wastewater and stormwater level of service (LOS) goals*** that are measurable, affordable, and consistent with local priorities.

- ***Identify programmatic and capital wastewater collection and stormwater management system alternatives*** that will approach the desired LOS goals for conveyance and water quality improvement. When necessary, data gaps needed to inform asset management decisions will be identified. Immediate opportunities to optimize existing assets or prioritize existing management activities will be also be evaluated.

- ***Identify wastewater treatment alternatives*** that can be used to improve plant operations, address regulatory drivers, and provide sustainable treatment practices.

- ***Develop a financial capabilitiy analysis (FCA) tool*** to evaluate the financial impacts of identified alternatives on the City's ratepayers, particularly those in disadvantaged communities. The City should be able to integrate results into the rate model and rate increases for IMP projects should be applied in the most affordable way possible.

- ***Prioritize program improvements and projects*** that provide the most environmental and public health benefits for the lowest cost to ratepayers.

Step 5 – Develop Recommendations and Schedule

Once alternatives are developed and their associated financial impacts are understood, the City and project team will work to identify the right set of alternatives analysis tools to assist in making confident and well-informed investment decisions in a transparent environment. One of the challenges of any decision-making process is appropriately comparing alternatives that have quantitative and qualitative benefits. A number of tools are available for doing these analyses and their applicability depends on the project context in which they are used.

Decision Analysis Approaches like the Triple Bottom Line Evaluation will Aid in Selecting Final IMP Alternatives

Relatively simple tools, such as a multi-criteria decision analysis or the industry-standard Triple Bottom Line (TBL) evaluation, could be used for the initial IMP phase. The TBL process uses a quantification process to evaluate the environmental, social, and economic impacts or benefits of alternatives. These approaches hinge on the assignment of priorities and ranks through a collaborative exercise. Given the importance of community outreach and collaboration in the integrated planning process, these tools will likely be well suited for use in the IMP.

Once selected, wastewater and stormwater alternatives will be compiled with findings from the previous steps into a summary document which will comprise the draft IMP. As described in Step 3, the project team will solicit input on the draft document from stakeholders and community leaders. Regulators will also be engaged throughout the IMP development process to keep them apprised of our approach and progress and get feedback while developing the plan. Input received from the community and regulators will be incorporated into the final IMP, as appropriate, before the plan is finalized and presented to the City Council.

Step 6 – Implement and Measure Success

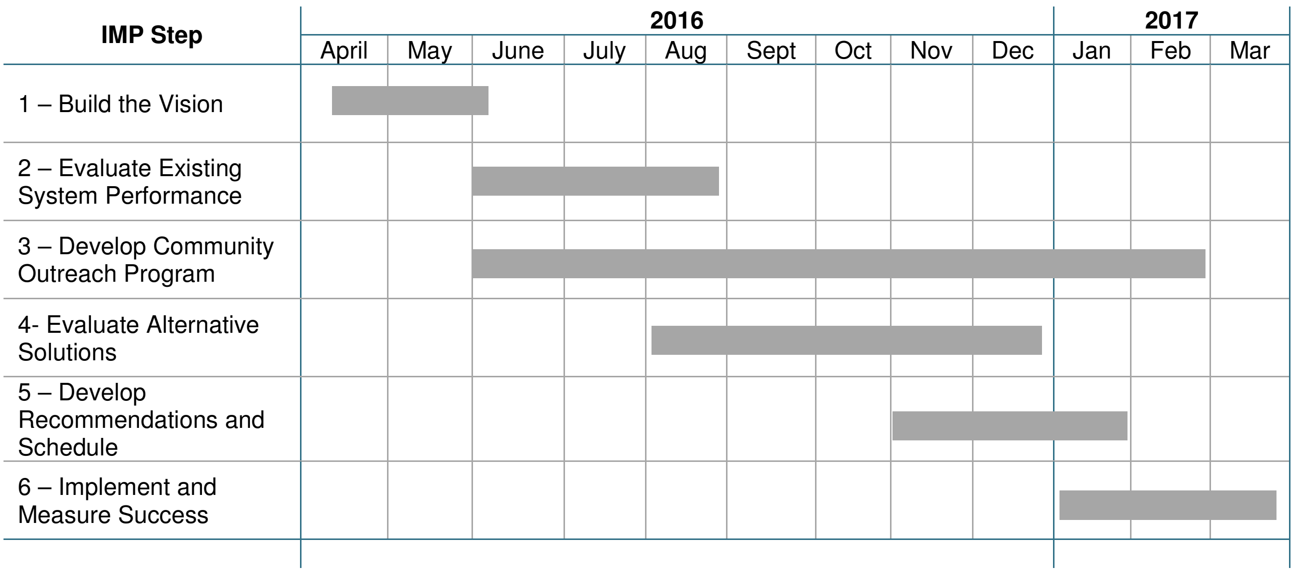
EPA recognizes that an adaptive management approach is key to successful integrated planning. This means monitoring and evaluating projects and practices as work proceeds, and adapting or revising plans and designs as appropriate based on lessons learned. Evaluating projects and practices as work proceeds can often be a more effective approach than adopting a monitoring program confined to the post-construction phase. The Columbia IMP will incorporate an adaptive management approach toward recommendations that align with the City's goals.

The development of an implementation schedule is another critical component of the overall plan because it is tied to funding and affordability. Through the alternatives analysis process, proposed improvements will be prioritized in order of importance using criteria developed by the City and stakeholders. The implementation schedule for specific projects will be sequenced based on the key project drivers.

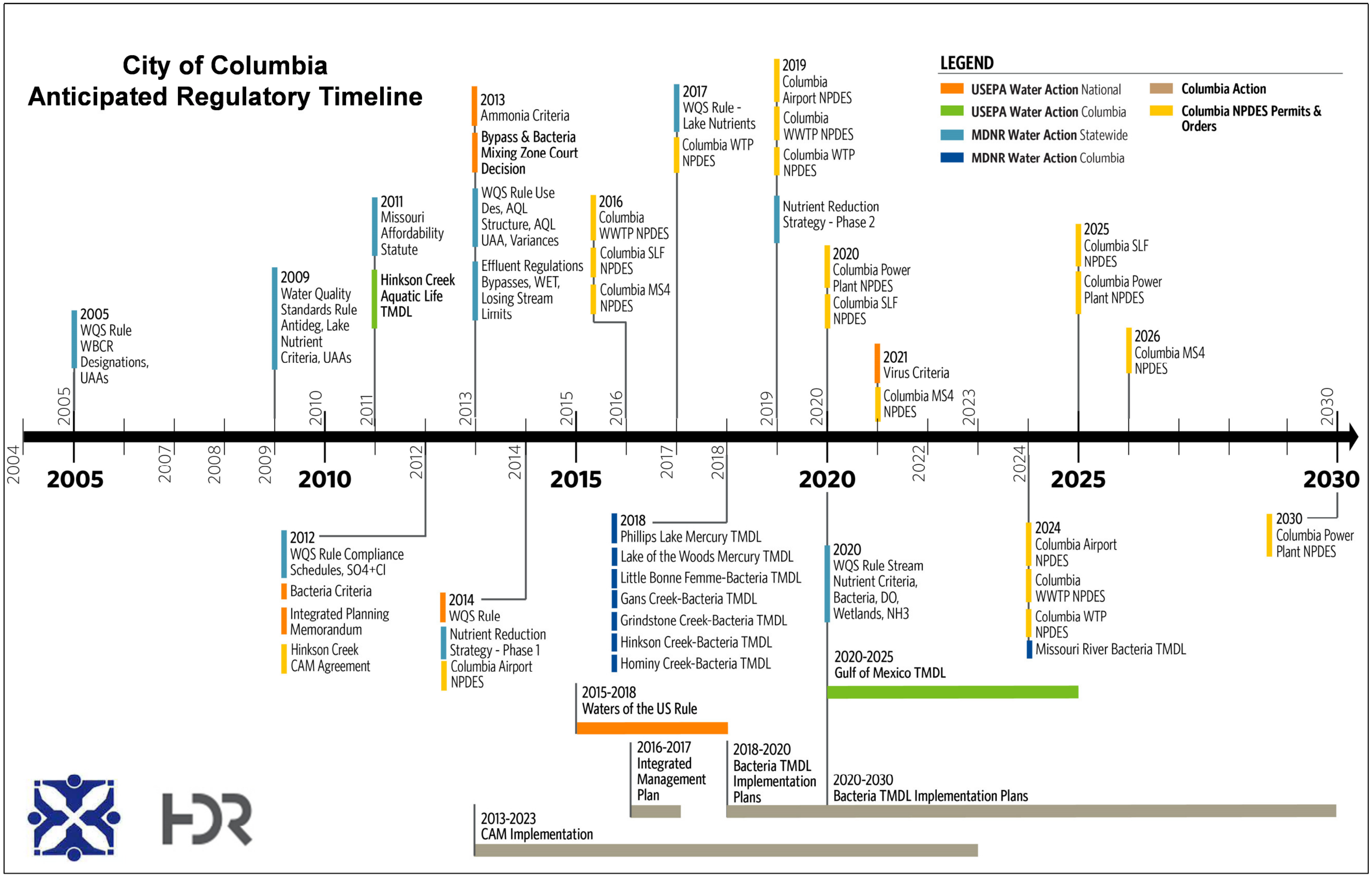
Anticipated Schedule

Information contained in this Framework will guide IMP project activities and the planning process going forward. The project is currently scheduled for a targeted completion date of March 2017, but is flexible to account for changes as the project evolves. In the coming months, the project team will work with City staff to develop a Community Outreach Plan and begin compiling, analyzing, and describing existing data to better understand performance characteristics of the City's current systems.

Anticipated Columbia IMP Project Schedule



Attachment A
City of Columbia's Anticipated Regulatory Timeline



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Columbia Wastewater and Stormwater IMP

Attachment D

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Our Columbia Waters
Integrated Management Plan
Wastewater & Stormwater

Columbia Wastewater and Stormwater Integrated Management Plan

Visioning Workshop Summary

HDR

Geosyntec consultants

Shockey Consulting Services, llc

TREKK DESIGN GROUP LLC

City of Columbia, MO

August 31, 2016

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Visioning Workshop Background

The City of Columbia, Missouri (City) is working to develop an Integrated Management Plan (IMP) for the City's wastewater and stormwater utilities. The IMP will be developed based on guidance presented in US Environmental Protection Agency's (EPA) June 2012 *Integrated Municipal Stormwater and Wastewater Planning Approach Framework*, and the Missouri Department of Natural Resources' (MDNR) *Missouri Integrated Planning Framework*. The goal of the IMP is to develop an adaptable and affordable long-term plan that addresses the City's wastewater and stormwater management needs and meets Clean Water Act requirements.

In May 2016, HDR Engineering, Inc. (HDR), and their team, which includes Geosyntec Consultants, Inc. (Geosyntec), Shockey Consulting Services, LLC (Shockey), Black and Veatch, Inc. (B&V), and TREKK Design Group, LLC (TREKK), facilitated a two-day Visioning Workshop to discuss existing and future challenges facing the City, goals and objectives of the IMP, and potential strategies to meet those goals. Workshop participants included representatives from a number of City Departments, including: City Management, Utilities Department, Columbia/Boone County Public Health and Human Services, Finance Department, Sustainability Office, Legal Department, and Community Relations. Representatives from the University of Missouri, Boone County, and the Boone County Regional Sewer District also participated.

During the two-day Workshop, the group discussed

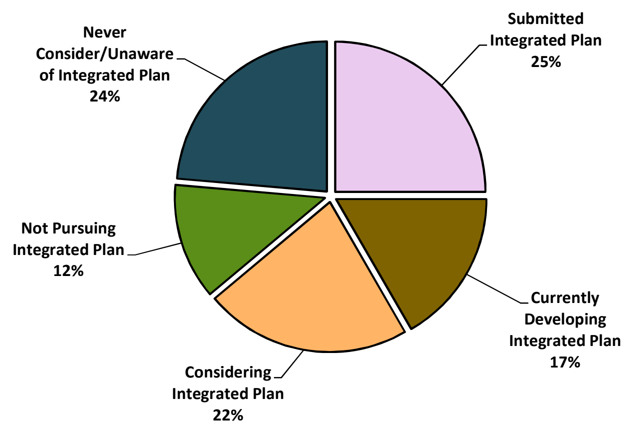
- Examples of IMP implementation across the country,
- State and federal regulatory drivers impacting the City,
- Affordabiltity concerns and strategies for accurately characterizing cost impacts on ratepayers,
- The current conditions and future expectations for the City's wastewater and stormwater systems,
- Methods commonly used to identify and prioritize wastewater and stormwater solutions during IMP development,
- Potential community outreach approaches and key stakeholder groups, and
- Goals and objectives of the IMP.

Following the Visioning Workshop, HDR and the City met individually with each member of the Columbia City Council and Mayor Treece to discuss the workshop results and confirm that the City's IMP vision best represents the diverse views, desires, and expectations of its residents. A summary of issues discussed during the Visioning Workshop and follow up meetings with Council, as well as key takeaways from the collective discussion, are included in the sections that follow. Results from the Workshop will serve as the foundation for the planning process going forward.

IMP Implementation Examples

Jeff Eger (HDR), Adrienne Nemura (Geosyntec), and Trent Stober (HDR) gave an overview of IMP activities to date both nationally and in Missouri. Jeff began by discussing integrated planning in the context of his experience as the Utility Director at Sanitation District No. 1 (SD1) of Northern Kentucky. Integrated planning is a "smart," community-driven process that allows municipalities to tailor infrastructure planning and investments to their needs and financial capability instead of the siloed, compliance-driven approach historically taken by EPA. As a result of communities like SD1 successfully using integrated planning principles to make environmental improvements and increase human health protection, EPA now supports integrated planning as a necessary and important approach to infrastructure planning.

Adrienne discussed national integrated planning progress. She began by discussing the results of a national integrated planning survey project Geosyntec is conducting for the Water Environment and Reuse Foundation. Thus far, the research has found that more than 40% of communities surveyed have submitted or are developing integrated plans. In general, these communities are pursuing integrated plans to cost-effectively address regulatory compliance requirements and affordability limitations in their communities. In some communities, roadblocks such as limited knowledge or lack of buy-in from management have prevented them from pursing integrated planning. These roadblocks are not present in Columbia.



Integrated Planning Survey Results
Courtesy of Geosyntec Consultants, Inc.

Trent presented the integrated planning process in Springfield. Springfield is the first community to pursue integrated planning in Missouri. Their plan is expansive and is designed to address all environmental issues, including water, air, and land use issue. They have been working for three years with stakeholders and experts to identify and characterize plan priorities. Springfield's process has been well-received by the regulatory agencies.

Key Workshop Discussion Takeaways

- EPA and MDNR support integrated planning. MDNR likely will recognize integrated plans in permit documents and associated Memorandums of Understanding (MOU) and adjust pemit conditions accordingly.
- MDNR permit writer turnover is a concern for the City so it will be important to get MDNR approval of the IMP. This will allow the City to be more in control of their planning and investment decisions.
- The City expects that stakeholder and community involvement will be critical to developing an effective IMP.

Regulatory Drivers

Trent Stober (HDR), Tom Wallace (Geosyntec), and David Carani (HDR) presented the existing and future state and federal regulatory drivers that will impact the City's wastewater and stormwater programs and permits. As the group explained, these drivers will influence the development, implementation, and ultimate success of the City's IMP.

Over the next five to ten years, MDNR will be implementing a number of regulation changes to improve consistency with federal requirements. These changes generally include

- New water quality requirements for small streams;
- Increasingly stringent ammonia, nutrient, and bacteria requirements for all streams, some lakes, and wetlands; and
- Additional reporting and assessment requirements for impaired waters in municipal separate storm sewer (MS4) service areas.

Summary of Regulatory Drivers Facing City of Columbia

Driver	Potential Impacts	Utility Impacted
2014 WQS Rule	- TMDLs for smaller streams - Better biological comparisons	MS4 Collection System
2017 WQS Rule	- Nutrient criteria to lakes >10 acres	MS4
2020 WQS Rule	- Eagle Bluffs water quality criteria - Stream nutrient impairments - Stringent bacteria criteria, impairments & TMDLs - Stringent ammonia criteria	MS4 WWTP Collection System
Bacteria Impairments	- Bacteria TMDLs	MS4 Collection System
Nutrient Loss Reduction Strategy	- Technology-based nutrient limits - Stormwater BMPs	WWTP MS4
Federal MS4 Remand	- Clear, specific & measureable permit requirements	MS4

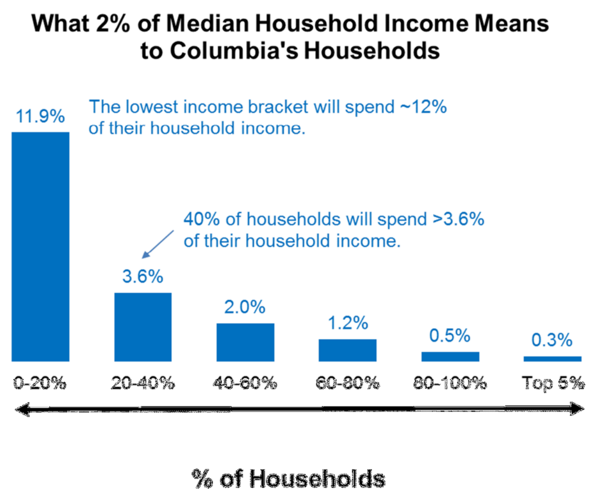
WQS – Water quality standards
TMDL – Total maximum daily load
MS4 – Municipal separate storm sewer system
WWTP – Wastewater treatment plant
BMP – Best management practice

Key Workshop Discussion Takeaways

- Regulatory uncertainty is one of the biggest challenges facing the City.
- Imminent changes to water quality criteria and discharge limit requirements in and around the Eagle Bluffs area could require substantial investments in the wastewater treatment plant (WWTP).
- New requirements in the City's MS4 permit include additional obligations in impaired watersheds.

Affordability Concerns

Adrienne Nemura (Geosyntec) discussed the role that affordability and financial capability play in the integrated planning process. As Adrienne explained, local governments are faced with the dual responsibility of addressing aging infrastructure to maintain acceptable levels of service while also planning for long-term compliance with uncertain, future regulatory requirements. These needs quickly outpace the generally limited financial resources available to many utilities, forcing the community to choose between service failures, regulatory violations, or unsustainable rate increases that strain ratepayers. Integrated planning allows communities to prioritize all of these needs in a way that is affordable to the community.



Maintaining Ratepayer Affordability is a Key IMP Goal

Thanks in part to the US Conference of Mayors, EPA is evolving on the issue of affordability. Historically, EPA considered wastewater project costs up to 2% of a community's median household income (MHI) to be affordable (up to 4.5% for water and wastewater). In Columbia, 2% of MHI is approximately $830 per year. With the introduction of the 2012 integrated planning framework and subsequent guidance, EPA has expanded on those guidelines and is open to considering other socioeconomic factors when measuring affordability. The Water Resources Development Act of 2016 (WRDA), which is moving forward in Congress, includes provisions to ensure that affordability determinations include holistic measurements of a community's socioeconomic conditions.

As Adrienne discussed, MDNR has developed a simple tool that provides a useful starting point for evaluating affordability in Columbia. However, this tool should be updated to consider not only the residential impacts of future IMP alternatives, but also the financial strength of the City's utility. Adrienne presented a number of metrics that can be evaluated to quantify these impacts as the IMP affordability tool is developed.

Key Workshop Discussion Takeaways

- Regulators have historically misapplied the 2% of MHI metric to justify requiring communities to spend more on infrastructure. Pending legislation (WRDA) encourages EPA to revisit their affordability guidelines.
- The methods for evaluating affordability are evolving away from simplistic comparisons to the MHI. New developments at the national level will ensure that future evaluations look at all relevant socioeconomic impacts.
- The City wants to ensure that the financial impacts to disadvantaged areas and residents of the community are carefully considered during IMP development.

Existing System Discussions

During the Workshop, the larger group divided into two smaller breakout sessions to discuss the existing wastewater and stormwater systems. The intent of these breakout sessions were to get general feedback about the integrated planning process and understand the specific challenges and priorities facing each of the specific programs. Trent Stober (HDR) lead the wastewater session and Eric Dove (HDR) lead the stormwater session. Takeaways from each breakout session are included below.

Key Wastewater Breakout Session Takeaways

- The wastewater utility has successfully upgraded, operated and maintained the existing facilities in a manner that keeps rates affordable. They efficiently address scheduled maintenance and work order issues and have improved their data management, inter-departmental collaboration, and customer responsiveness.
- The IMP will be successful by
  - Balancing affordability concerns with regulatory obligations,
  - Comprehensively engaging community stakeholders, and
  - Educating users on the importance and value of wastewater services.
- The highest wastewater priorities that must be considered are maintaining public health protections, meeting level of service (LOS) goals, and providing justification for dedicated funding for certain activities. Specifically, the City would like to
  - Address wet-weather issues, including basement backups, sanitary sewer overflows (SSOs), and areas with persistent inflow and infiltration (I&I) challenges;
  - Reduce capacity limitations in the existing treatment and collection systems; and
  - Develop and implement an asset management system to support system renewal efforts, including a mechanism to establish sufficient dedicated funding for these efforts.
- The greatest challenges facing the wastewater utility include
  - The lack of fuding for renewal efforts,
  - The uncertainty of future regulations, and
  - Differentiating and communicating the importance of wastwater services to the community amidst other infrastructure discussions taking place in the City.

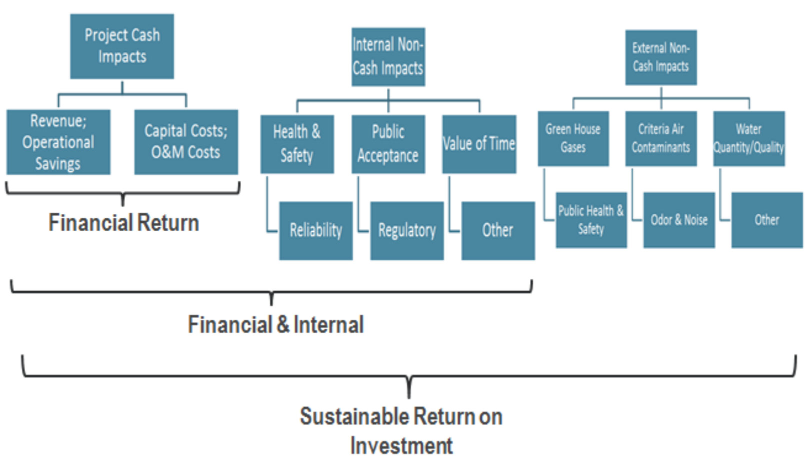
Key Stormwater Breakout Session Takeaways

- The stormwater utility successfully collaborates with other departments and implements creative projects on a limited budget. The IMP should consider and build on these successes.
- The IMP should be realistic and implementable. In other words, it must be technically-feasible, prioritized, funded, and supported by the community. Specifically, the IMP will be successful if it provides a means to
  - Implement existing projects over the next five years, and
  - Develop and fund important projects to meet long-term goals.
- Many of the stormwater utility's greatest challenges are also their highest priorities for the IMP. These include the following:
  - Prioritizing projects. Historically, projects have been reactionary in nature. The group wants to reach a point where projects that provide multiple benefits can be prioritized.

- Asset management. An asset management program would help to develop performance baselines, measure progress, justify funding, educate stakeholders on direct and indirect impacts of stormwater, and ensure that customer's LOS expectations are met.
- Funding and community education. The last funding increase was insufficient to address all of the existing needs but communicating the urgency to stakeholders is difficult.
- Coordination and planning. The City needs to develop projects to address upcoming drivers (MS4 permit, Hinkson Creek mitigation bank, etc.) but lacks a recent stormwater master plan that would help formalize those projects and effectively coordinate their implementation with other departments.

Prioritizing Alternatives

Trent Stober (HDR) presented on a variety of decision making tools that the City could use to help evaluate and prioritize wastewater and stormwater alternatives identified during the IMP process. As Trent explained, one of the challenges of any decision making process is appropriately comparing alternatives that produce both quantitative and qualitative benefits. A number of tools are available for doing these analyses and their applicability depends on the project context in which they are used. For example, simple weighting systems used as part of a multi-criteria decision analysis (MCDA) are suitable for planning level evaluations of individual projects. More complex approaches, such as the Sustainable Return on Investment (SROI) tool, are better suited for holistically monetizing the costs and benefits of a suite of projects.



Rating Systems can be Developed to Prioritize Pollution Sources and Improvement Opportunities

Trent explained that the City of Springfield is currently using the MCDA and SROI approaches as part of their integrated planning process. In Springfield, an MCDA weighting system is being used to identify and prioritize pollution sources and improvement opportunities based on input from the Environmental Priorities Task Forces. Once the MCDA process is complete, Springfield plans to use the SROI process to evaluate the impacts of selected alternatives.

Key Workshop Discussion Takeaways

- The City pointed out that the weighting and decision making processes associated with MCDA-type approaches are attractive because they are effective and easy for the public to understand.

- Community input is a big component but technical justification is important when weighting and selecting alternatives.
- The City is familiar with using the SROI process on non-sewer related projects but it is a detailed process that may or may not be too complicated for the IMP.

Community Engagement

Sheila Shockey (Shockey) lead discussions about the importance of engaging the community in the IMP. As Sheila explained, integrated planning is largely a community-driven process. Therefore, developing the appropriate key messages and communicating them in the correct format are critical for effectively gathering and considering community input. The key messages should clearly articulate issues the IMP will address and explain how the citizens will benefit from its implementation.

The group also discussed the importance of coordinating community engagement efforts with critical stakeholders, such as the Columbia Mayor, City Council, City staff, and the Columbia Water and Light Integrated Water Resource Plan (IWRP) committee to ensure that all members are informed and their time and efforts are used most efficiently. The group identified a number of other environmental, social, and business-oriented groups that could be included to get a wide variety of input in the process. Specific organizations include:

- Missouri Department of Conservation
- Audubon Society
- Missouri River Relief
- Sierra Club
- Hinkson Collaborative Adaptive Management Stakeholders
- PedNet
- Downtown Columbia Leadership Council
- Columbia Chamber of Commerce
- Lawn Care Companies
- Local Developers
- Central Missouri Community Action Center
- Churches
- Central Missouri Opportunity Council
- University of Missouri
- League of Women Voters of Columbia-Boone County
- Neighborhood Associations and Home Owners

Key Workshop Discussion Takeaways

- We will have to get community input on public health and safety concerns in addition to environmental issues.
- Outreach efforts should focus on getting high-level, value-based input from the community.
- In addition to coordinating with other existing committees, we will have to consider using a mix of electronic and traditional community outreach tools to reach a wide variety of stakeholders.

Setting Goals and Objectives

Drawing from information presented and discussed over the course of the two-day workshop, Sheila Shockey (Shockey) and Jeff Eger (HDR) facilitated group discussions to help generate a shared set of goals and objectives for the IMP. As part of the session, the group collaborated to develop the following vision statement:

> ***The stormwater and wastewater Integrated Management Plan is a community-driven, affordable infrastructure plan that enhances human health and safety, water quality, economic vitality, and environmental resources by leveraging our existing assets and implementing innovative solutions.***

The intent of the vision statement is to clearly and effectively communicate the intent and desired outcomes of the IMP to community stakeholders. This vision statement will serve as the basis for the project going forward. In addition to developing the vision statement, the group worked together to identify and prioritize a preliminary set of issues that should be addressed in the IMP. These issues will serve to initially focus IMP project activities, but may be modified based on technical input or community engagement efforts over the course of the project.

Key Workshop Discussion Takeaways

- Because the vision statement will serve as the basis for the project going forward, it should clearly establish what the IMP is, what it will do, and how it will do it.
- The group organized preliminary issues into three categories according to importance. Some of the issues included the following:
    - Tier 1 (most important) – basement backups, SSOs, I&I issues, asset management, affordability, strengthening the MS4 program, and addressing the WWTP discharge.
    - Tier 2 – green infrastructure, new and redevelopment runoff management, and getting ahead of new regulations.
    - Tier 3 (least important) – adding experienced staff, implementing controls on private property, and addressing water quality issues.

Next Steps

Input gathered during the two-day Visioning Workshop will inform all aspects of IMP development going forward. The project is currently scheduled for a targeted completion date of March 2017, but is flexible to account for changes as the project evolves. In the coming months, the project team will work with City staff to develop a Community Outreach Plan and begin compiling, analyzing, and describing existing data to better understand performance characteristics of the City's current systems.

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Columbia Wastewater and Stormwater IMP

Attachment E

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Our Columbia Waters
Integrated Management Plan
Wastewater & Stormwater

Technical Memorandum 1

Surface Water Quality and Biological Conditions

Columbia Wastewater and Stormwater Integrated Management Plan

Columbia, Missouri
February 2, 2017

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Section 1. Introduction and Objectives

The City of Columbia, Missouri (City) is working to develop an Integrated Management Plan (IMP) for the City's wastewater and stormwater utilities. The goal of the IMP is to develop an adaptable and affordable long-term plan that addresses the City's wastewater and stormwater management needs and meets Clean Water Act requirements. The IMP will be developed based on guidance presented in US Environmental Protection Agency's (EPA) *Integrated Municipal Stormwater and Wastewater Planning Approach Framework* (Stoner 2012).

A critical step in the IMP includes evaluating the City's environmental resources and infrastructure assets to better define the existing condition, performance, and needs of its systems. This evaluation is important because it forms the basis for identifying priorities and developing alternatives in subsequent phases of the IMP. To develop a comprehensive understanding of existing conditions, the City and their project team compiled and evaluated existing surface water, wastewater, and stormwater data. These data, as well as current operation and maintenance practices and procedures, were then reviewed and discussed in a series of workshops. Results from these efforts are documented in the following technical memoranda:

- Technical Memorandum 1 – Surface Water Quality and Biological Conditions
- Technical Memroandum 2 – Wastewater Collection System Assessment
- Technical Memorandum 3 – Wastewater Treatment System Assessment
- Technical Memorandum 4 – Stormwater System Assessment

Columbia is widely known for its urban area streams and lakes. These streams and lakes are prominent natural features that support wildlife habitat and recreational opportunities. The State of Missouri has established water quality standards for streams and lakes, including those in Columbia. These standards are implemented by the Missouri Department of Natural Resources (MDNR) and specify surface water quality that is considered protective of both aquatic life and public health. If surface water quality standards are not met in a stream or lake, the City may be required to take corrective action if the impairment is attributed to activities within the City's jurisdictional area. Therefore, understanding current water quality conditions in Columbia area streams is critical for establishing priorities through the IMP process.

Surface water quality has been measured in many of Columbia's streams and lakes. The purpose of this memorandum is to summarize surface water quality data collected in the Columbia area and compare these measurements to Missouri's applicable water quality standards. This comparison will inform the IMP process by identifying observed water quality challenges or potential impairments that may be addressed through future corrective actions or water quality management strategies. It can also be used to help prioritize projects, including projects that may help protect existing water quality.

Section 2. Surface Water Resources and Current Impairments

There are approximately 300 miles of streams and more than 100 public and private lakes[1] within the 200 square miles (128,000 acres) of watersheds that adjoin or intersect the City (**Attachment A**). There are six major streams in the Columbia area (Hinkson Creek, Hominy Branch, Grindstone Creek, Gans Creek, Little Bonne Femme, and Flat Branch) which support various forms of recreation and aquatic life.

Section 303(d) of the federal Clean Water Act requires each state to periodically identify waters not meeting water quality standards that protect designated beneficial uses. Designated beneficial uses associated with waters in the Columbia area include: whole body contact recreation (e.g., swimming), secondary contact recreation (e.g., fishing, wading), protection of warm water aquatic life, human health-fish consumption and livestock and wildlife watering. The most recent MDNR 303(d) list of impaired waters (MDNR 2016) includes several lakes and streams within and around the Columbia area (**Table 1**). The most common designated beneficial use impairment in Columbia area waters is whole body contact recreation, or swimming.

Table 1. Waterbodies with Existing Water Quality Impairments.

Listing Year	WBID	Water Body	Class	Impaired Size (miles/*acres)	Pollutant	Source	Impaired Uses	Status
2016	1007	Hinkson Creek	P	7.6	*E. coli*	Nonpoint source	WBC-B	TMDL Needed
1998	1007	Hinkson Creek	P	6	Unknown	Urban Runoff	AQL	[1]TMDL Approved
2012	1008	Hinkson Creek	C	18.8	*E. coli*	Runoff from: Forest/Grassland/Parkland/Rural, Residential Areas	WBC-A	TMDL Needed
1998	1008	Hinkson Creek	C	6.3	Unknown	Urban Nonpoint Source	AQL	[1]TMDL Approved
2012	1011	Hominy Branch	C	1.0	*E. coli*	Runoff from: Forest/Grassland/Parkland/Rural, Residential Areas, Urban Runoff/Storm Sewers	WBC-B	TMDL Needed
2006	1009	Grindstone Creek	C	2.5	*E. coli*	Runoff from: Forest/Grassland/Parkland/Rural, Residential Areas, Urban Runoff/Storm Sewers	WBC-A	TMDL Needed
2012	1004	Gans Creek	C	5.5	*E. coli*	Rural Nonpoint Source	WBC-A	TMDL Needed
2012	1003	Little Bonne Femme Creek	P	9.0	*E. coli*	Source Unknown	WBC-B	TMDL Needed
2008	7628	Perry Phillips Lake	UL	*32.0	Mercury in Fish Tissue	Atmospheric Deposition - Toxics	GEN	TMDL Needed
2002	7436	Lake of the Woods	L3	*3.0	Mercury in Fish Tissue	Atmospheric Deposition - Toxics	HHP	TMDL Needed

[1]Hinkson Creek TMDL (MO_1007 and _1008) Dated 01/28/2011
Class P = Streams that maintain permanent flow even in drought periods.
Class C = Streams that may cease flow in dry periods but maintain permanent pools which support aquatic life.
Class UL = Unclassified Lake
Class L3= Other lakes which are waters of the state. These include both public and private lakes. For effluent regulation purposes, publicly-owned L3 lakes are those for which a substantial portion of the surrounding lands are publicly owned or managed.
WBC-A = Whole Body Contact Recreation A
WBC-B = Whole Body Contact Recreation B
GEN = General Criteria
HHP = Human Health Protection
AQL = Protection of Aquatic Life

[1] U.S. Geological Survey, 2007-2014, National Hydrography Dataset available on the World Wide Web (http://nhd.usgs.gov), accessed 8/11/2016.

As a means to restore beneficial uses, MDNR schedules and develops a Total Maximum Daily Load (TMDL) to address each impairment. The TMDL calculates the amount of the identified pollutant (load) a waterbody can assimilate while still being protective of the beneficial uses. Load allocations for the pollutant are then assigned to each identified point or non-point source, and an implementation plan to reduce loads is established.

In 1998, two segments of Hinkson Creek were placed on the 303(d) list for an aquatic life (AQL) impairment. A phased and adaptive TMDL was developed and approved by the US Environmental Protection Agency (EPA) in January 2011. MDNR, EPA, the City of Columbia, Boone County, and the University of Missouri entered into a "Collaborative Adaptive Management" (CAM) agreement to holistically approach the complexities and uncertainties of the Hinkson Creek aquatic life impairment.

Other impairments include *Escherichia coli* (*E. coli*) and mercury in fish tissue. These have been added to the list over the last 10 years and are currently scheduled to have TMDLs developed before the end of 2017 (MDNR 2016), although the timing is subject to change.

Section 3. Point Source Discharges

Point source discharges include wastewater treatment plant, industrial treatment, and stormwater outfall discharges that require a National Pollutant Discharge Elimination System (NPDES) permit issued by MDNR. Point sources may potentially contribute to diminished water quality and are therefore important to this surface water quality evaluation.

NPDES permits are issued for both urbanized area stormwater and wastewater. Within the Columbia area, there are 259 NPDES permitted stormwater outfalls for land disturbance activities such as road construction or development. Fifty-two permitted stormwater outfalls associated with industrial activities are located throughout the area. There are 46 NPDES permitted outfalls[2] classified as industrial (8) or domestic wastewater treatment (38) in the area (**Attachment B**), with 4 of the domestic wastewater outfalls located within City limits. Of the 38 domestic wastewater treatment NPDES permits, 11 are in the process of decommissioning and joining either the City or Boone County Regional Sewer Districts systems.

The City is also responsible for operation and maintenance of a Municipal Separate Storm Sewer System (MS4). This system collects stormwater from streets, yards and parking lots and conveys this stormwater to streams located throughout the City.

[2] 2015 MDNR NPDES Outfall Layer. *MO_2015_NPDES_Outfalls_shp*. Missouri Spatial Data Information Service. University of Missouri - Columbia.

Section 4. Surface Water Quality Characterization

Surface water quality and hydrological data were gathered from available sources including the MDNR water quality database, the City and Boone County Health Department records, US Geological Survey (USGS) gauging stations, and the Missouri Spatial Data Information Service (MSDIS). Data were then compiled into databases for further analysis. Water quality data were reviewed to determine whether data were suitable and of sufficient quantity to include in the water quality evaluation. Monitoring stations (**Attachment C, Table 2**) were considered suitable and sufficient if more than one measurement was collected from a site within the last 10 years[3].

Table 2. Surface Water Quality Data Summary.

Parameter	Monitoring Stations	Number of Samples
E. coli	50	1,080
Dissolved Oxygen	79	380
Chloride	44	201
Ammonia	59	180
Total Nitrogen	49	255
Total Phosphorus	49	255

4.1. Bacteria

E. coli is a type of fecal coliform bacteria present in the intestines of animals and humans. The presence of *E. coli* in water serves as an indicator of potential human or animal waste contamination and is measured in colonies per 100 milliliters (CFU/100mL). Human and animal waste has the potential to contain many types of disease-causing pathogens (Kander, 2014). The levels of these indicator bacteria for which MDNR has determined that there is a low risk of illness from ingestion or contact are set as the water quality standard or criterion (**Table 3**). The bacteria criterion for each waterbody (streams and lakes) is based on the applicable contact recreation uses, which are assigned based on waterbody conditions and public accessibility (Kander, 2014). In addition, the bacteria criteria for Missouri, which are expressed as a seasonal geometric mean, are only applicable during the established recreational season (April 1 to October 31).

[3] An exception was made to the 10-year timeframe suitability to include chloride data collected between 1994 and 1995 for a University of Missouri research project (Perkins1995) that illustrated seasonal variations. Data from Hinkson Creek and Flat Branch collected on May 29, 2012 in response to the Brookside Apartment fires were also excluded from the evaluation.

Table 3. E. coli Criteria for Recreational Beneficial Use Designations (10 CSR 20-7.031 Water Quality Standards).

Beneficial Use	Beneficial Use Description	Recreational Season Criterion[1] (CFU/100mL)
Whole Body Contact - A	Waters that have been established by the property owner as public swimming areas welcoming access by the public for swimming purposes and waters with documented existing whole body contact recreational use(s) by the public.	126
Whole Body Contact - B	Waters designated for whole body contact recreation not contained within category A	206
Secondary Contact	Uses include fishing, wading, commercial and recreational boating, any limited contact incidental to shoreline activities, and activities in which users do not swim or float in the water.	1,134

[1]Criterion expressed as a recreational season (April 1 thru October 31) geometric mean.

Consistent with observations that fecal indicator bacteria are pervasive in streams (UWRRC, 2014), *E. coli* was detected in all stream samples included in this evaluation. Data were grouped by monitoring location to assess annual variability in Hinkson Creek and Little Bonne Femme Creek and their primary tributaries (**Figure 1**), and long-term trends in individual stream segments (**Figure 2**) and lakes (**Figure 3**). *E. coli* data along Hinkson Creek indicate an upward trend from upstream to downstream, and express annual variability over the last three years (**Figure 3**). UWRRC (2014) noted bacteria data in urban stormwater were highly variable in urban streams over time. Flat Branch Creek, a tributary of Hinkson Creek, typically exhibits higher annual bacteria levels than other locations in the Hinkson Creek watershed.

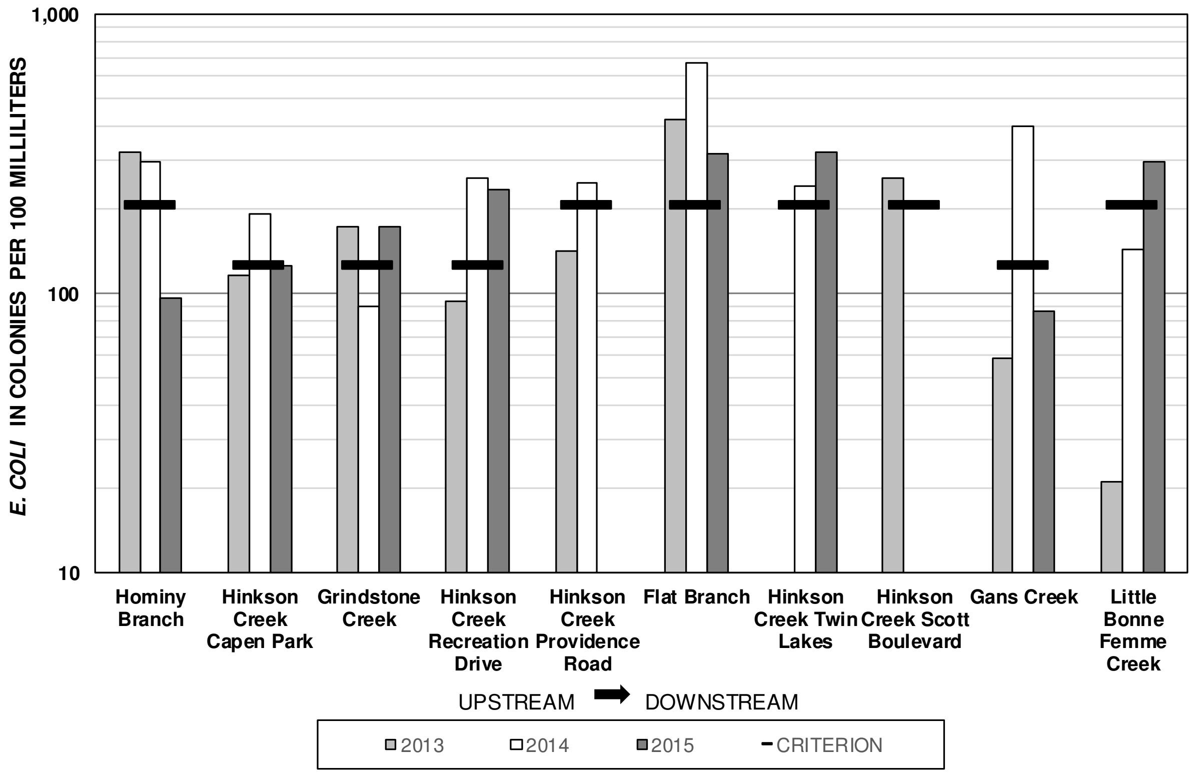

Figure 1. Geometric Mean Bacteria Levels Measured in Local Watersheds from Upstream to Downstream from 2013 to 2015. Hominy Branch (2013), Hinkson Creek at Capen Park (2013 and 2014), Hinkson Creek at Recreation Drive (2013), Hinkson Creek at Providence Road (2013 and 2014), Hinkson Creek at Scott Boulevard (2013), and Gans Creek (2013) data are represented by less than 5 data points.

Bacteria levels are typically elevated during wet weather flows in all rivers and streams and may be attributed to sources such as stormwater discharges from MS4s, sanitary sewer overflows, illicit discharges to storm sewer systems, failing or improperly located onsite septic systems, wastewater treatment plants, wildlife, domestic pets, agriculture, and other sources. A summary of bacteria measurements during wet and dry weather conditions was developed for Hinkson Creek and Little Bonne Femme Creek watersheds (**Figure 2**). The distinction between wet and dry weather was based on Hinkson Creek flow data as measured at the USGS gauge station below Providence Road. Periods when the daily average flow was greater than the long term median (50th percentile) flow value were considered wet weather influenced. Nearly all streams met the designated contact recreation criterion during dry weather flows. However, wet weather measurements were several orders of magnitude higher. Flat Branch Creek did not express this same characteristic. In fact, dry weather bacteria levels were greater than wet weather levels.

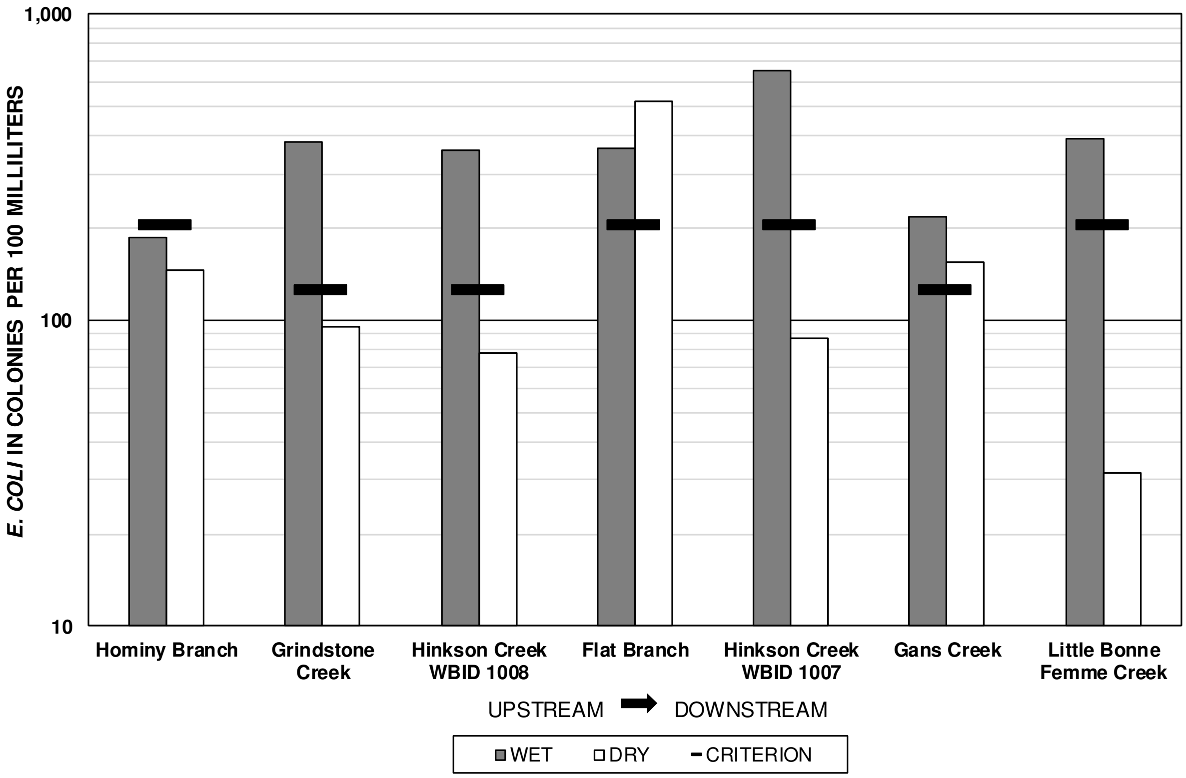

Figure 2. Long Term Wet Weather Characterization of Seasonal Geometric Mean Bacteria Levels in Streams, 2006-2015. Data assessment includes all available data within the last 10 years.

As previously discussed, *E. coli* criteria are expressed as a recreational season geometric mean. However, MDNR also advises against swimming at public beaches (lakes and streams) when a measurement exceeds 190 CFU/100 mL. East Hulen Lake, Finger Lakes, Katy Lake, Shalimar Gardens, and Stephens Lake have had single sample bacteria levels above the MDNR maximum advisory threshold for public swimming beaches (**Figure 3**).

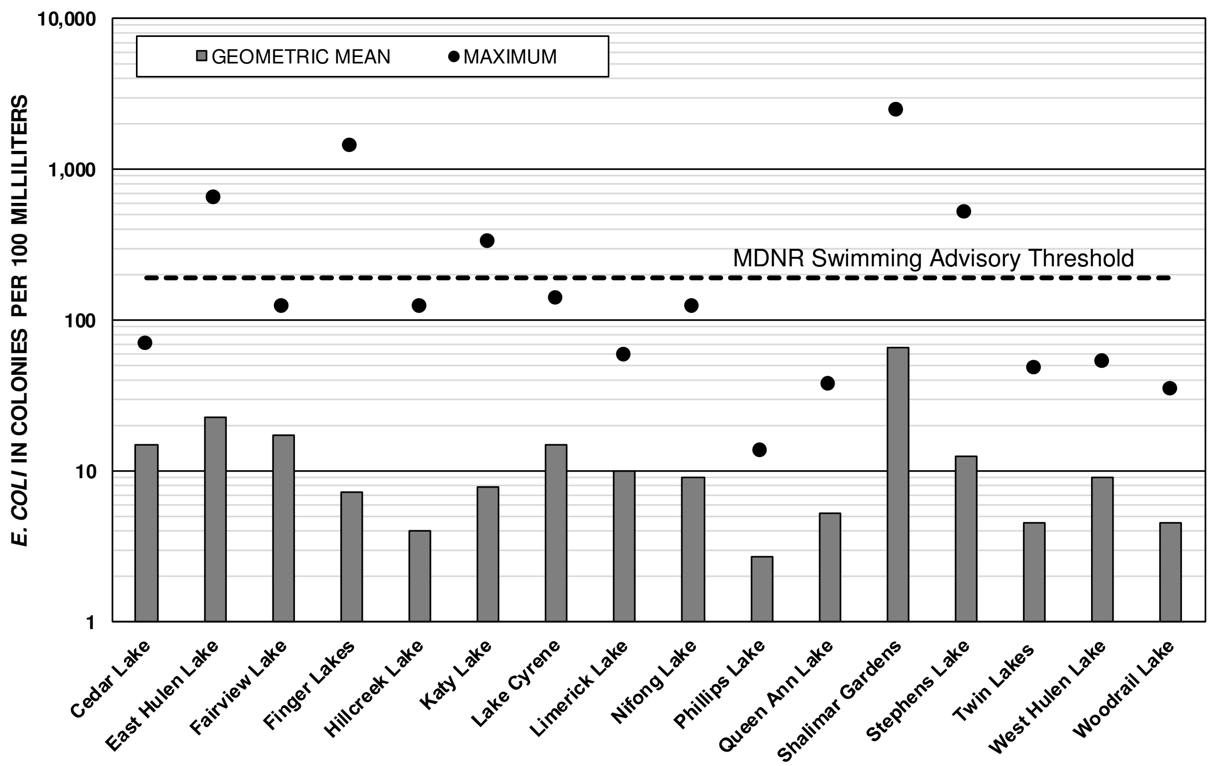

Figure 3. Seasonal Bacteria Levels in City and Local Watershed Lakes, 2006-2015.

4.2. Dissolved Oxygen

Dissolved oxygen (DO) is necessary in streams and lakes to support aquatic life. MDNR has established a water quality standard of 5.0 milligram per liter (mg/L) as a minimum concentration (10 CSR 20-7.031) for the protection of aquatic life in warm water fisheries. However, EPA's suggested criteria for ambient water quality (EPA, 1987) indicate DO levels can drop below 5 mg/L at times and not adversely affect aquatic organisms. MDNR considers a stream impaired for DO when more than 10% of collected DO measurements fall below this water quality criterion (MDNR LMD 2018).

DO data from the past 10 years were evaluated against the criterion. This evaluation indicated that 335 of 363 (92%) individual lake and stream DO samples were at or above 5.0 mg/L. Dissolved oxygen measurements below 5.0 mg/L most often occurred during the summer seasons when low stream flows and high water temperatures naturally limit a waterbody's ability to maintain high DO levels, although DO levels are impacted by a number of other factors such as organic matter, flow conditions, stream shading, and others.

Average DO concentrations from streams in the Columbia area ranged from 6.1 mg/L (Little Bonne Femme) to 9.7 mg/L (Hinkson Creek WBID 1008, **Figure 4**). Flat Branch Creek and Little Boone Femme Creek 10^{th} percentile DO concentrations (90% of the data exceed this value) were below the 5 mg/L DO criterion. Hinkson Creek exhibits higher DO concentrations in the upper segment (WBID 1008) compared to the lower segment (WBID 1007).

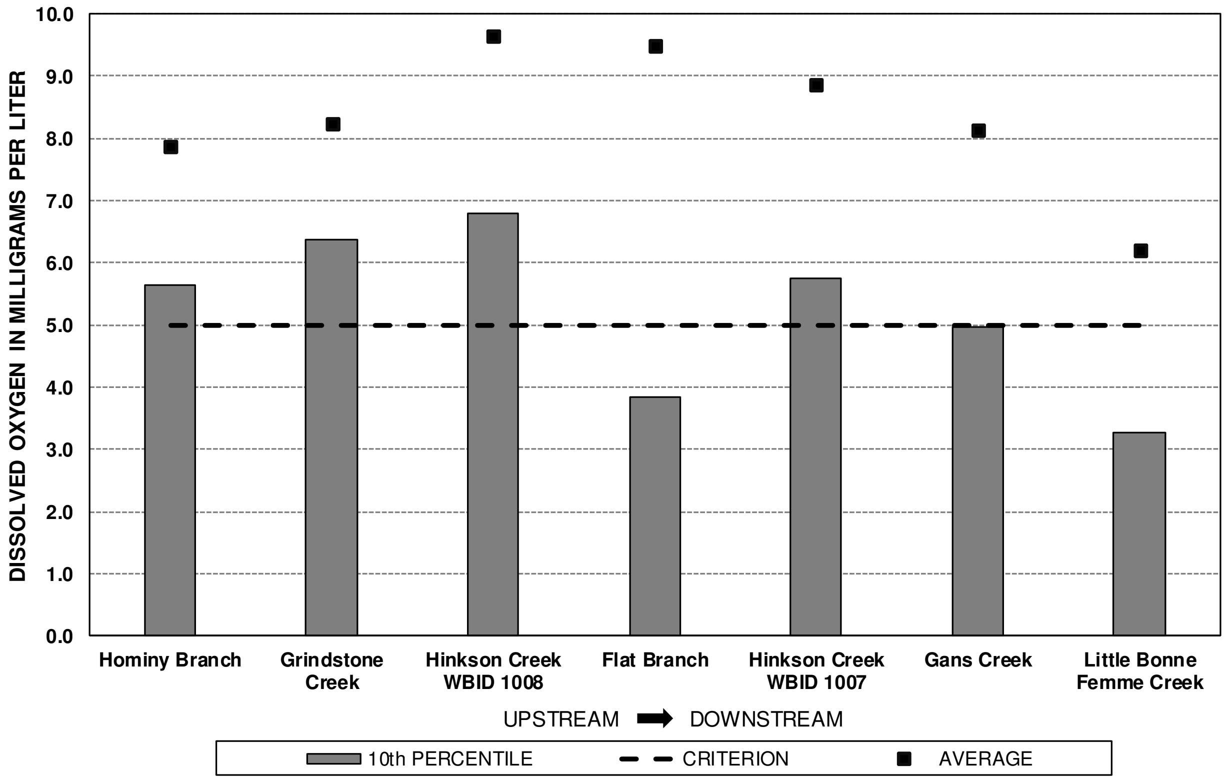

Figure 4. Summary of DO Concentration Measurements in the Hinkson Creek and Little Bonne Femme Creek Watersheds. Hinkson Creek locations were grouped according to their appropriate WBID to evaluate potential longitudinal differences in DO concentrations.

4.3. Chloride

Chloride concentrations in urban streams often become elevated from runoff associated with de-icing materials applied to roads during the winter months (MDNR, 2004). Calcium and Sodium chloride are the typical de-icing compounds applied to private and public sidewalks, roadways and parking lots. Elevated chloride concentrations may adversely affect aquatic biological communities and alter species composition (Starke et al., 2000). The water quality criterion for acute and chronic chloride is 860 mg/L and 230 mg/L, respectively. MDNR considers more than one chronic and/or acute criterion exceedance within the last three years as impairment for aquatic life protection.

Nearly 200 chloride samples from streams and lakes in the Columbia area were evaluated. Chloride measurements were collected during a year-long study conducted on Hinkson Creek below Providence Road from 1994 to 1995 by the University of Missouri (Perkins 1995). Overall, monthly chloride concentrations are below applicable criteria, with increasing concentrations during the winter season (**Figure 5**). Measured chloride concentrations exhibit seasonal trends related to winter road treatment. This observation is further supported by a 2010 – 2011 Hinkson Creek study (Nichols et al., 2016) where average chloride concentrations measured from October to March (range 50 mg/L to 128 mg/L) were appreciably greater than averages observed from April to September (range 15 to 55 mg/L).

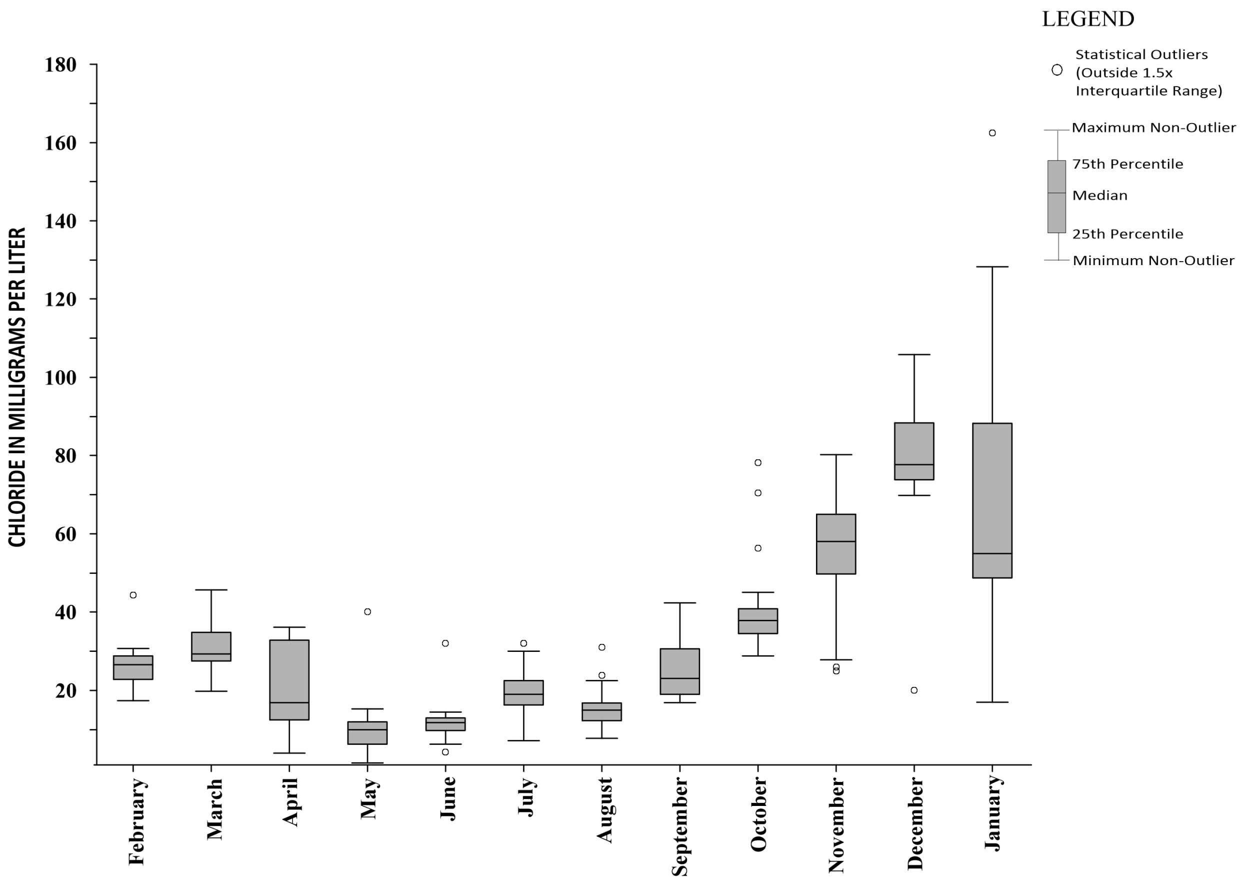

Figure 5. Monthly Chloride Concentration Ranges as Measured in Hinkson Creek below Providence Road between 1994 and 1995 (Perkins 1995).

Chloride concentrations within the last 10 years were also evaluated for trends in other streams in the Hinkson Creek watershed. Available data were not sufficient to discern temporal trends. However, average and maximum concentrations (**Figure 6**) indicate an increasing gradient from the upstream segment (WBID 1008) to the downstream segment (WBID 1007) of Hinkson Creek (Nichols et al., 2016). The same trend is evident when comparing maximum chloride concentrations from upstream to downstream in tributaries along Hinkson Creek. Overall, average chloride concentrations were low, with Flat Branch having the highest average concentrations. Recently, a University of Missouri study (as cited in Hooper, 2015) concluded that maximum chloride concentrations in Hinkson Creek may exceed the acute and chronic criterion during winter and spring runoff events.

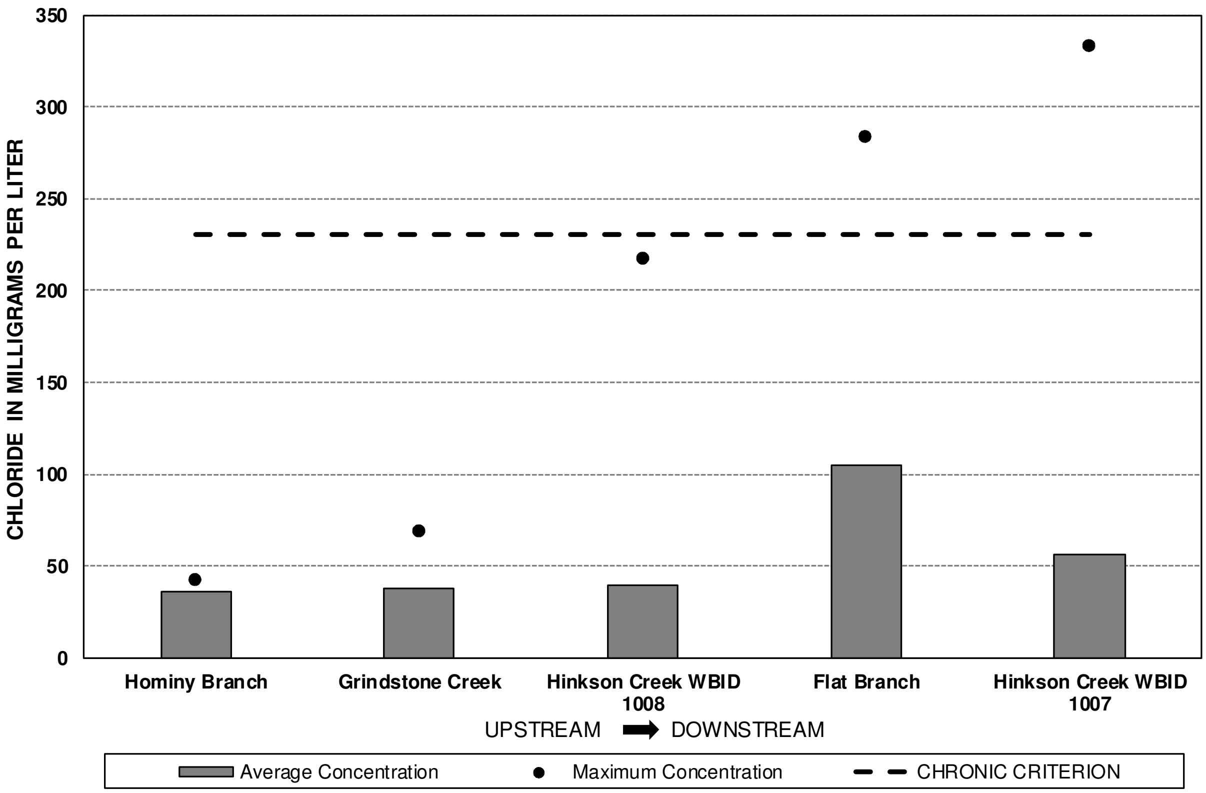

Figure 6. Chloride Concentrations in the Hinkson Creek Watershed.

4.4. Ammonia

Ammonia is a form of nitrogen that exists in aquatic environments and can have toxic effects to aquatic life. Ammonia sources can include fertilizers, industrial applications, decomposition of organic matter, animal and human waste. The default criteria for acute and chronic ammonia are 12 mg/L and 1.5 mg/L. However, actual criteria are based on the pH and temperature of the surface water at the time of sample collection. MDNR considers more than one chronic or acute ammonia criterion exceedance within the last three years as impaired for aquatic life protection.

There were 180 ammonia samples evaluated for temporal and spatial trends but results were inconclusive. Samples in the Columbia area were infrequently high with maximum values typically associated with special stream studies conducted by MDNR for evaluation of small point source discharges outside of the City limits. With the exception of the special stream studies, the maximum ammonia concentration in the Columbia area was 0.64 mg/L. Overall average ammonia concentrations were relatively low, ranging from 0.02 mg/L (multiple locations) to 0.16 mg/L (Hinkson Creek below Forum Blvd). This is consistent with other ammonia data collected on Hinkson Creek (Zeiger and Hubbart, 2015).

4.5. Nutrients

Nutrients, including total nitrogen (TN) and total phosphorus (TP), are natural and necessary elements of aquatic ecosystems. However, when nutrients become over abundant they can cause significant negative impacts to lakes and streams (EPA Nutrient Pollution website).

Currently, Missouri does not have nutrient water quality criteria for most stream, rivers, and most lakes. However, EPA has developed suggested thresholds based on monitoring data from high quality streams and the geographical locations of those waterbodies throughout the United States. EPA recommends that states develop numeric nutrient criteria for different water body types, but recognizes the difficulty of developing scientifically-defensible criteria (EPA, 2011). For streams in the Columbia area (Ecoregion 9, Sub-Ecoregion 72[4]), suggested thresholds are 0.75 mg/L for total nitrogen and 0.083 mg/L for total phosphorus (EPA, 2000).

Average TN concentrations at individual monitoring stations ranged from 0.28 mg/L at Hinkson Creek near Highway 63 to 1.02 mg/L at Hinkson Creek below Forum Boulevard. Stream segment average TN concentrations (**Figure 7**) ranged from 0.3 mg/L (Flat Branch) to 0.61 mg/L (Hominy Branch). Average TN concentrations in Columbia area streams were generally below EPA's suggested threshold values except for those observed at Hinkson Creek at North Rogers Road (Zeiger and Hubbart, 2015).

Average TP concentrations measured at individual monitoring stations in the Columbia area range from 0.02 mg/L (Hinkson Creek at Broadway) to 0.11 mg/L (Hinkson Creek near I-70) . Between 2010 to 2013, Zeiger and Hubbart (2015) observed average TP concentrations in Hinkson Creek also fell within this range. Stream average TP concentrations (**Figure 8**) ranged from 0.05 mg/L (Lower Hinkson Creek, WBID 1007) to 0.07 mg/L (Flat Branch). Average and maximum TP concentrations were below EPA's suggested thresholds in evaluated Columbia area streams.

[4] The City of Columbia is split between Sub-Ecoregion 40 and 72. Sub-Ecoregion 72 values were chosen because the intersection of the Upper Hinkson Creek (WBID 1008) and Lower Hinkson Creek (WBID 1007) fall within it.

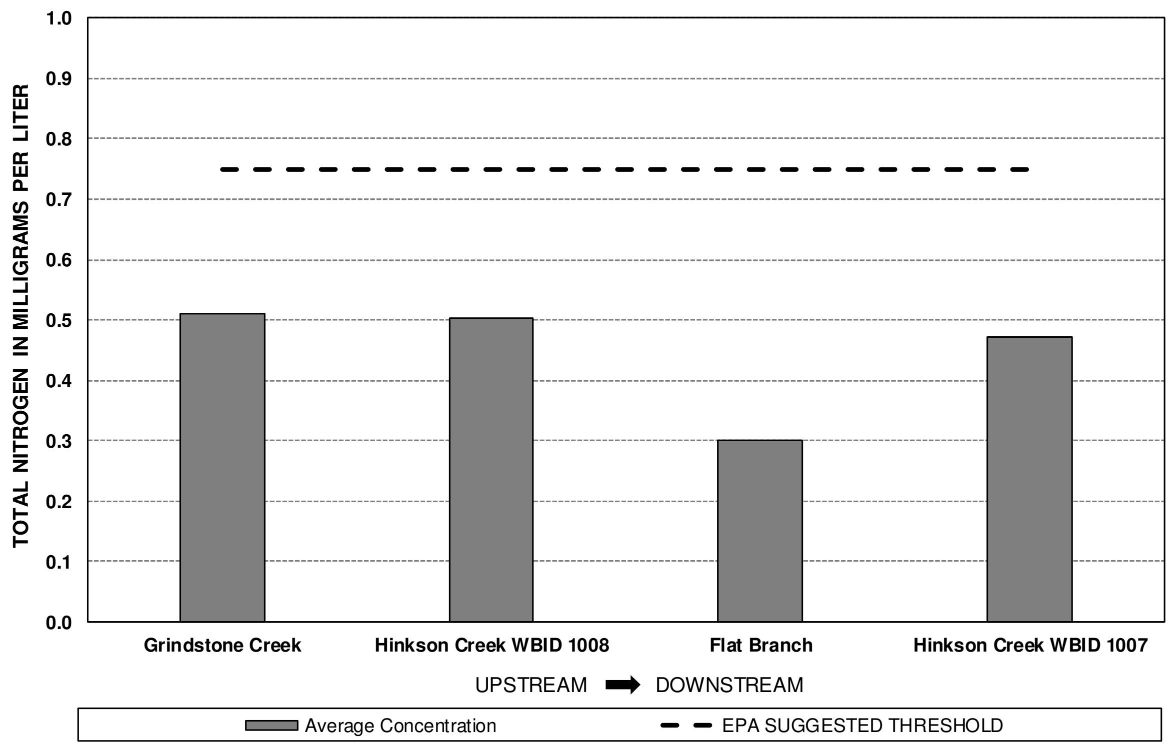

Figure 7. Total Nitrogen Concentration in Columbia Area Streams.

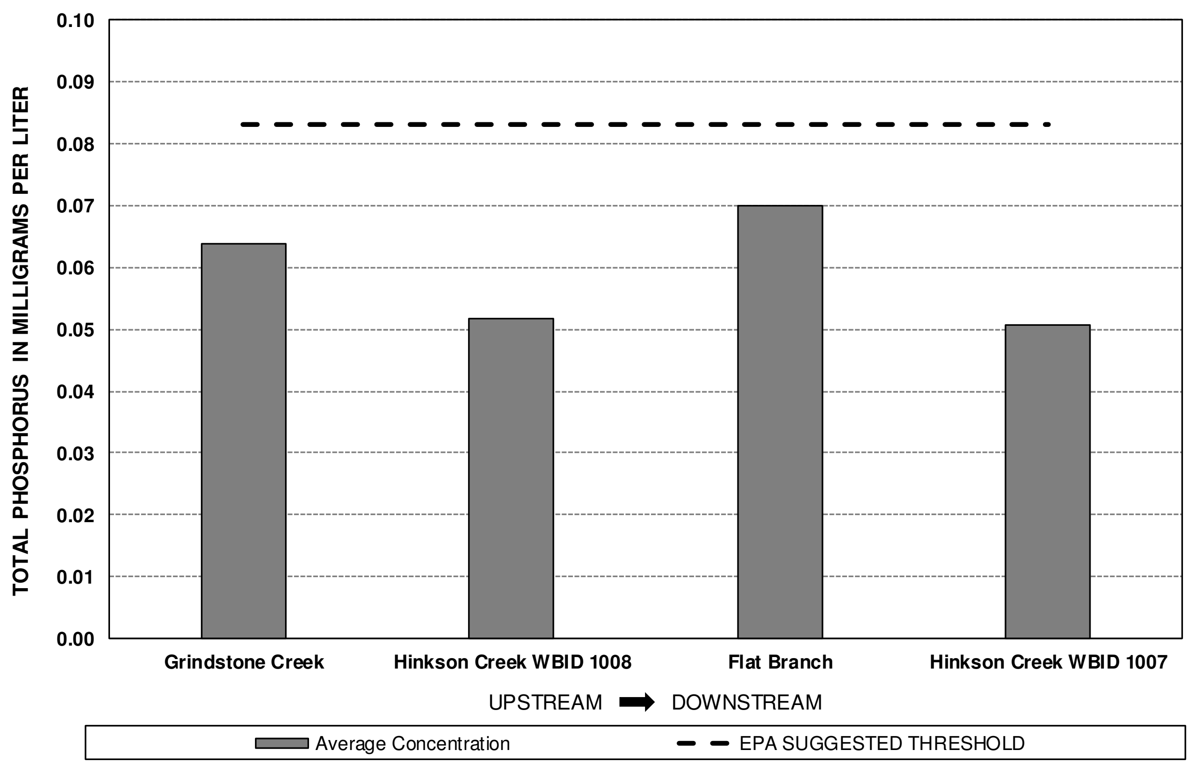

Figure 8. Total Phosphorus Concentration in Columbia Area Streams.

4.6. Macroinvertebrates

Aquatic macroinvertebrates are used as an indicator of stream water quality. Samples have been collected from Hinkson Creek since 2001. In 2012, MDNR launched a 5-year intensive monitoring program on Hinkson Creek in response to an EPA-approved aquatic life TMDL. During the 5-year study, MDNR is assessing annual spring and fall macroinvertebrate community composition (MDNR, 2012-2014).

Aquatic macroinvertebrate community evaluations are expressed as the Missouri Stream Condition Index (MSCI), which is comprised of four biological metrics: Taxa Richness (TR), Ephemeroptera/Plecoptera/Trichoptera Taxa (EPTT), Biotic Index (BI), and the Shannon Diversity Index (SDI). Together, these metrics consider stream health and adjust to changes in environmental stream conditions. In calculating the MSCI score, each of the four metrics is standardized and assigned values of 1, 3 or 5, with 5 representing optimum conditions. **Table 4** outlines the ranges and biological relevance of the metric derived MSCI scores.

Table 4. Missouri Stream Condition Index Breakdown.

Minimum Range	Maximum Range	Biological Indicator
16	20	Fully Supports Aquatic Life Uses
10	14	Partially Supports Aquatic Life Uses
4	8	Does Not Support Aquatic Life Uses

Historically, all sampling locations in the upper (WBID 1008) and lower (WBID 1007) reaches of Hinkson Creek have attained partially supporting or fully supporting MSCI scores. MSCI scores are typically higher in the upstream reach than in downstream reach however, the downstream reach did demonstrate fully supporting conditions in the Fall of 2015 (**Attachment D**). The EPTT is generally the biological metric influencing MSCI scores for both the upper and lower reaches of Hinkson Creek. MDNR uses Bonne Femme Creek as a control stream for comparing MSCI scores collected from Hinkson Creek. Since 2012, MSCI scores measured at Bonne Femme Creek have been comparable to those measured at all Hinkson Creek stations.

4.7. State Parks and Conservation Areas

Water quality data within local and state parks/conservation areas were reviewed as part of the evaluation. Several City park streams and lakes had *E. coli* maximum values above MDNR's swimming advisory level (190 CFU/100 mL) but nutrients were generally low.

Eagle Bluffs Conservation Area (Eagle Bluffs) is a 4,400 acre wetland and wildlife area managed by the Missouri Department of Conservation (MDC). Wetlands and open water comprise approximately 1,700 acres of the area. To maintain this critical wetland habitat, a near constant source of water is required. The City and MDC have an operational understanding by which the Columbia Regional Wastewater Treatment Plant (CRWWTP) provides treated effluent to constantly maintain wetland and open water habitat. This agreement represents one of the nation's most prominent projects reclaiming wastewater effluent for wildlife habitat creation. Effluent quality is described in *Technical Memorandum 3 – Wastewater Treatment System Evaluation*.

Section 5. Summary

Understanding stream and lake water quality in the Columbia area is critical for prioritization of resources and corrective actions. Water quality data for Columbia area streams and lakes were reviewed to assist in prioritizing potential water quality concerns and identifying waters which may benefit from strategies focused on water quality improvement or protection. Water quality conditions identified in the assessment include:

- Surface water quality data have been collected in a number of Columbia area streams and lakes and are sufficient for evaluating large scale patterns and trends. However, the limited quantity of data available from most sites generally prevents the robust and detailed analysis needed to identify potential pollution sources or areas of concern. Hinkson Creek's main stem has the most extensive dataset. Data for Columbia area lakes were limited and primarily included bacteria, few lakes had information related to other parameters discussed.

- Columbia area streams and lakes have several impaired beneficial uses (whole body contact recreation, aquatic life, etc). Most of the impairments are related to whole body contact recreation and the result of elevated *E. coli* levels which MDNR could address through the TMDL process. A TMDL has been developed for aquatic life use impairments in Hinkson Creek and is being implemented through the ongoing CAM process. Impairments related to atmospheric deposition of mercury are a widespread issue statewide.

- Elevated *E. coli* levels are pervasive throughout Columbia area waters, which is typical in urban waters. Seasonal geometric mean criteria for *E. coli* were exceeded during one or more of the last three years (2013, 2014, 2015) and during wet weather in all streams evaluated. Lake *E. coli* levels were typically below the seasonal criteria but individual samples occasionally exceeded advisory thresholds.

- DO in Columbia area streams and lakes typically met state water quality criteria. However, Flat Branch, Gans Creek, and Little Bonne Femme Creek data indicate that depressed DO levels are present primarily during warm weather and low-flow conditions. The impacts of depressed DO levels on aquatic organisms in these streams is unclear.

- Chloride concentrations are generally low in Columbia streams. However, levels increase during winter and early spring during runoff events. Data were not sufficient to determine if water quality criteria were attained.

- Total nitrogen and total phosphorus levels in streams were below EPA's suggested ecoregional thresholds.

- Macroinvertebrate MSCI scores for Hinkson Creek indicate the upstream segment is typically fully supporting of aquatic life uses while the downstream segment is generally partially supporting of aquatic life.

- The continued use of the CRWWTP treated effluent is critical to the management strategies being implemented at Eagle Bluffs. Without this constant source of water, MDC would have to rely on the costly and energy-intensive practice of pumping several million gallons per day of Missouri River water to maintain water levels within Eagle Bluffs.

Section 6. References

EPA, 2001. Ambient Water Quality Criteria Recommendations: Information Supporting the Development of State and Tribal Nutrient Criteria for Rivers and Streams in Nutrient Ecoregion 9. Office of Water, Washington, DC. EPA 822-B-01-012. December 2001.

EPA, 2011. Working in Partnership with States to Address Phosphorus and Nitrogen Pollution through Use of a Framework for State Nutrient Reductions. Nancy K. Stoner to Regional Administrators, Regions 1-10. March 16, 2011.

EPA Nutrient Pollution website, https://www.epa.gov/nutrientpollution/problem, accessed September 4, 2016.

Hooper, L. 2015. A Stream Physical Habitat Assessment in an Urbanizing Watershed of The Central U.S.A. Master's Thesis, Graduate School, University of Missouri – Columbia.

Kander 2014. 10 CSR 20-7. Code of State Regulations, Department of Natural Resources, Division 20, Clean Water Commission Chapter 7, Water Quality. Office of the Secretary of State. Jefferson City, MO. January 29, 2014.

MDNR, 2004. Stream Survey Sampling Report. Hinkson Creek Stream Study Columbia, Missouri Boone County November 22, 2004. Missouri Department of Natural Resources Air and Land Protection Division Environmental Services Program.

MDNR 2012 – 2014. Hinkson Creek Macroinvertebrate Community Assessments (Years 1 through 3). Biological Assessment Report. Missouri Department of Natural Resources Division of Environmental Quality, Environmental Services Program, Water Quality Monitoring Section

MDNR, 2016. Missouri Integrated Water Quality Report and Section 303(d) List, 2016. Clean Water Act Sections 303(d), 305(b), and 314. Missouri Department of Natural Resources, Water Protection Program. April 7, 2016.

MDNR, 2016. Methodology for the Development of the 2018 Section 303(d) List in Missouri. Water Protection Program. Jefferson City, MO.

Nichols et al., 2016. John Nichols, Jason A. Hubbart, Barry C. Poulton, Using macroinvertebrate assemblages and multiple stressors to infer urban stream system condition: a case study in the central US, Urban Ecosystems, 2016, 19, 2, 679

Perkins, B. 1995. Temporal variability in a Midwestern stream during spring. Master's Thesis, Graduate School, University of Missouri – Columbia.

Stark, J.R., Hanson, P.E., Goldstein, R.M., Fallon, J.D., Fong, K.E., Lee, A.L., Kroening, S.E., and Andrews, W.J., 2000, Water Quality in the Upper Mississippi River Basin, Minnesota, Wisconsin, South Dakota, Iowa, and North Dakota, 1995–98: U.S. Geological Survey Circular 1211, 35 p., on-line at http://pubs.water.usgs.gov/circ1211/

Stoner, N. and C. Giles. 2012. Integrated Municipal Stormwater and Wastewater Planning Approach Framework. June 5, 2012. Washington DC.

UWRRC, 2014. Urban Water Resources Research Council of the Environmental and Water Resources Institute of the American Society of Civil Engineers. (2014). *Pathogens in Urban* Eds. J. Clary, B. Steets, and R. Pitt. *Stormwater Systems*. Prepared with support from the Urban Drainage and Flood Control District and the Urban Watersheds Research Institute. August.

Zeiger, S., and J.A. Hubbart. 2015. Nested-Scale Nutrient Yields from a Mixed-Land-Use Urbanizing Watershed. Hydrological Processes. DOI: 10.1002/hyp.10716

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Technical Memorandum 1

Attachments

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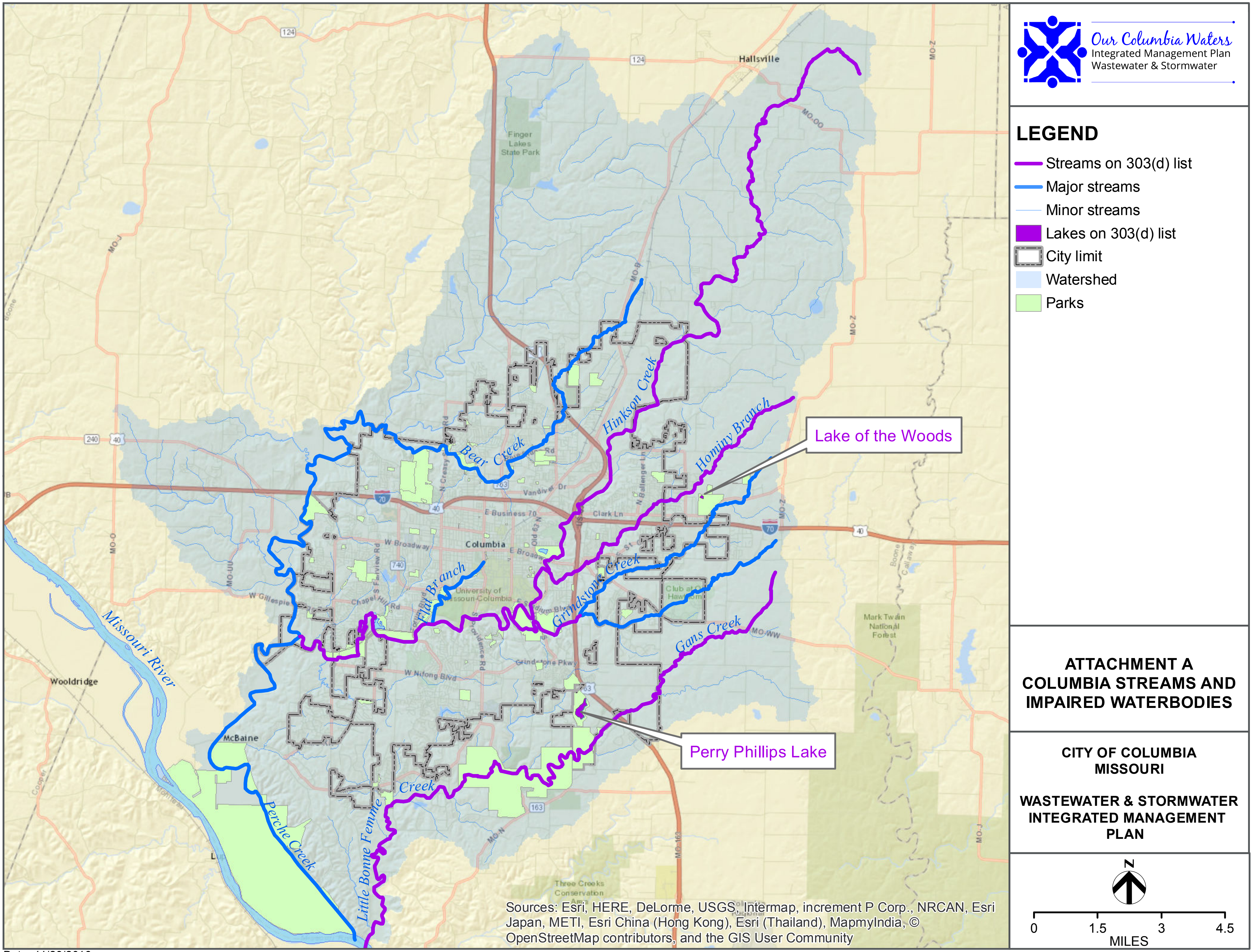
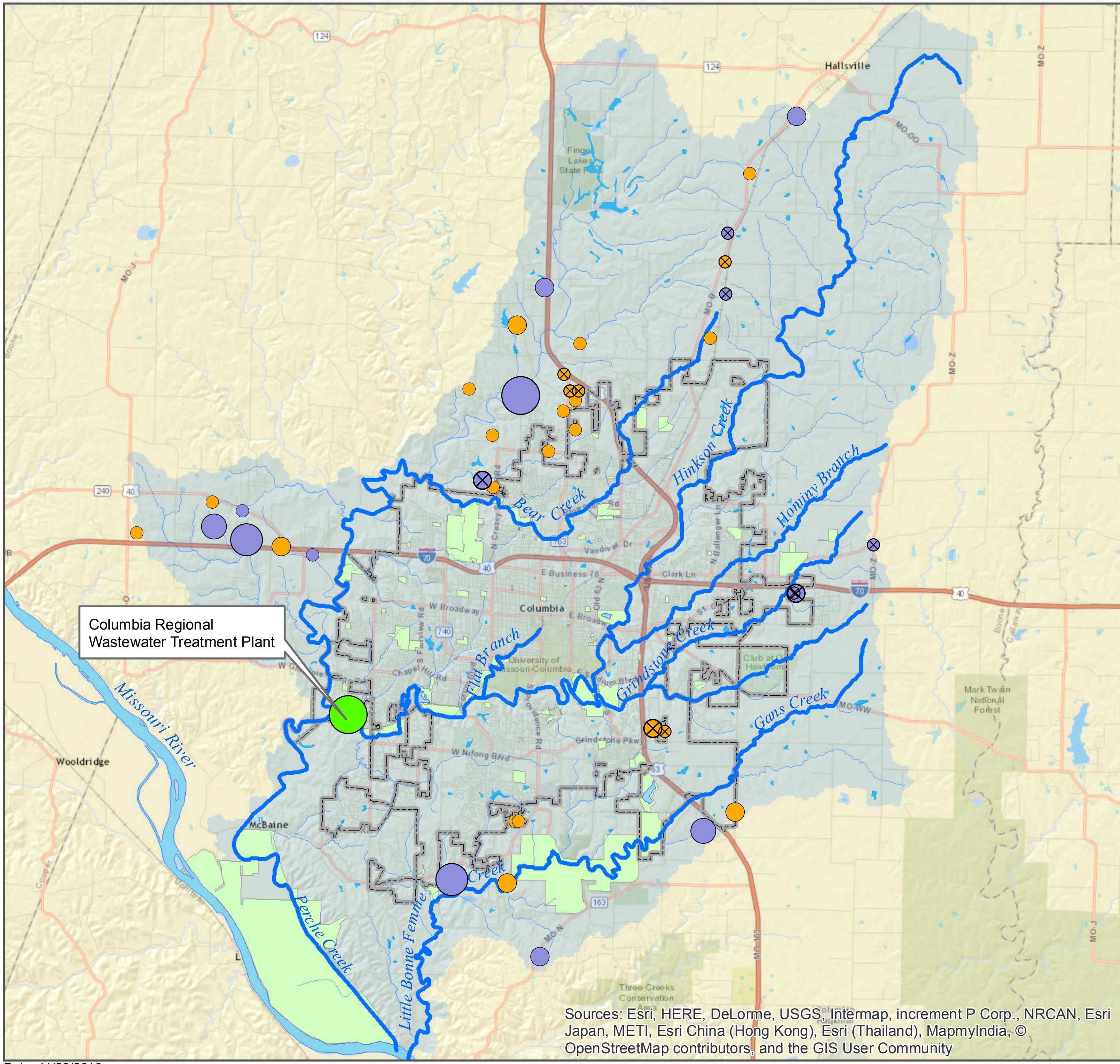


ATTACHMENT A
COLUMBIA STREAMS AND IMPAIRED WATERBODIES

CITY OF COLUMBIA MISSOURI

WASTEWATER & STORMWATER INTEGRATED MANAGEMENT PLAN

Date: 11/29/2016



Date: 11/29/2016

Our Columbia Waters
Integrated Management Plan
Wastewater & Stormwater

LEGEND

- Major streams
- Minor streams
- Water bodies
- Watershed
- City limit
- Parks

Treatment System Owner

- Boone County Regional Sewer District
- City of Columbia
- Private Systems
- Planned to be Consolidated

Treatment System Flow (GPD)

- 0 - 10,000
- 10,001 - 50,000
- 50,001 - 100,000
- 100,001 - 250,000
- 250,001 - and greater

**ATTACHMENT B
DOMESTIC WASTEWATER
TREATMENT SYSTEMS**

**CITY OF COLUMBIA
MISSOURI**

**WASTEWATER & STORMWATER
INTEGRATED MANAGEMENT
PLAN**

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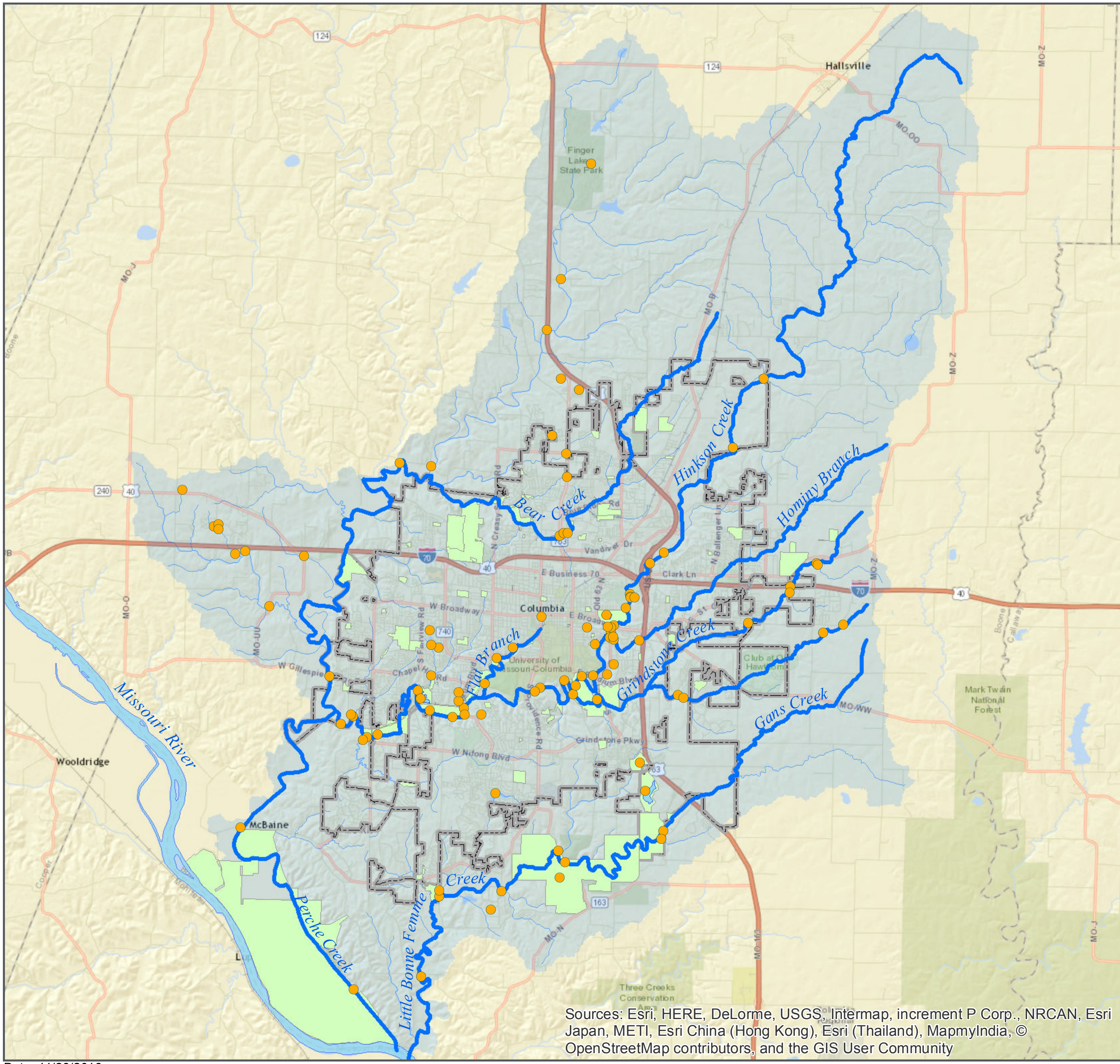


Our Columbia Waters
Integrated Management Plan
Wastewater & Stormwater

LEGEND

- Water quality stations
- Major streams
- Minor streams
- City limit
- Watershed
- Parks

ATTACHMENT C
COLUMBIA WATER QUALITY MONITORING STATIONS

CITY OF COLUMBIA MISSOURI

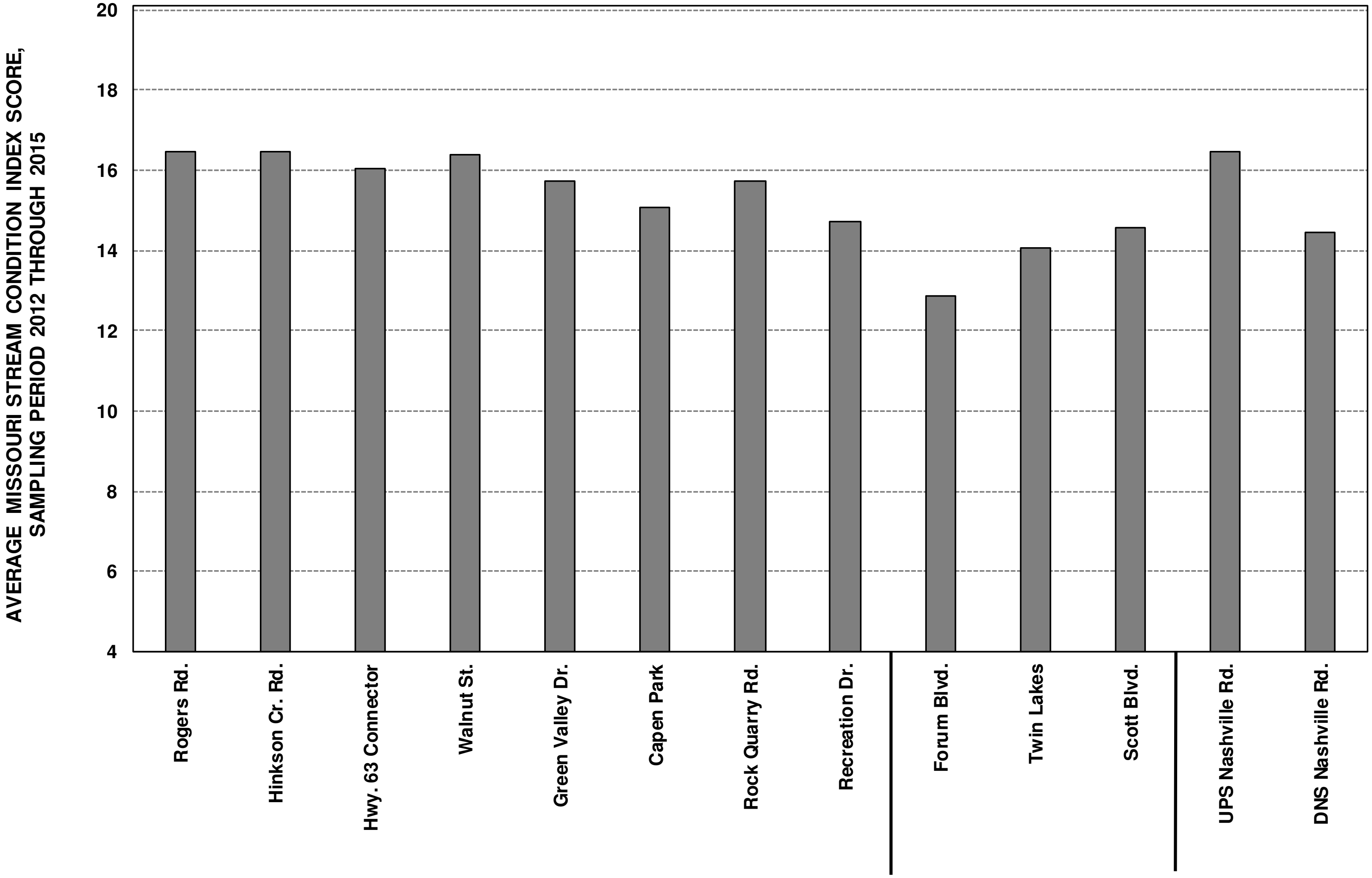
WASTEWATER & STORMWATER INTEGRATED MANAGEMENT PLAN

N

0 1.5 3 4.5
MILES

Date: 11/29/2016

Attachment D
Hinkson Creek and Bonne Femme Creek MSCI Scores



Note: Blank cells indicate that no macroinvertebrate sample was collected; **Shaded and Bolded** cells indicate a sample was collected and fully supports aquatic life; “- -“ indicates a sample was collected but not included in the MDNR evaluation; Unshaded and no bold indicates partial supporting of aquatic life. Fall 2012 data have been excluded by MDNR due to drought conditions during the summer of 2012.

Columbia Wastewater and Stormwater IMP

Attachment F

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Our Columbia Waters
Integrated Management Plan
Wastewater & Stormwater

Technical Memorandum 2
Wastewater Collection System Assessment

Columbia Wastewater and Stormwater Integrated Management Plan

Columbia, Missouri
February 2, 2017

HDR

Geosyntec consultants

Shockey Consulting Services, llc

TREKK DESIGN GROUP, LLC

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Section 1. Introduction and Objectives

The City of Columbia, Missouri (City) is working to develop an Integrated Management Plan (IMP) for the City's wastewater and stormwater utilities. The goal of the IMP is to develop an adaptable and affordable long-term plan that addresses the City's wastewater and stormwater management needs and meets Clean Water Act requirements. The IMP will be developed based on guidance presented in US Environmental Protection Agency's (EPA) *Integrated Municipal Stormwater and Wastewater Planning Approach Framework* (Stoner 2012).

A critical step in the IMP includes evaluating the City's environmental resources and infrastructure assets to better define the existing condition, performance, and needs of its systems. This evaluation is important because it forms the basis for identifying priorities and developing alternatives in subsequent phases of the IMP. To develop a comprehensive understanding of existing conditions, the City and their project team compiled and evaluated existing surface water, wastewater, and stormwater data. These data, as well as current operation and maintenance practices and procedures, were then reviewed and discussed in a series of workshops. Results from these efforts are documented in the following technical memoranda:

- Technical Memorandum 1 – Surface Water Quality and Biological Conditions
- Technical Memorandum 2 – Wastewater Collection System Assessment
- Technical Memorandum 3 – Wastewater Treatment System Assessment
- Technical Memorandum 4 – Stormwater System Assessment

This purpose of this memorandum is to summarize findings from the wastewater collection system assessment. The wastewater collection system is a critical element of the infrastructure owned and operated by a City's wastewater utility. Effective management of the collection system is vital for meeting important goals like reducing sanitary sewer overflows (SSOs), achieving regulatory compliance, efficiently managing the utility, and ensuring customer satisfaction. On August 9 and 10, representatives from HDR Engineering, Inc. (HDR), met with City staff to discuss these goals and identify the City's priorities and level of service (LOS) expectations. Results from the collection system assessment are documented in the sections that follow.

Note that this review was not intended to serve as a regulatory compliance audit or detailed assessment of program health and safety practices. Rather, the scope of this assessment was to review and characterize the City's current collection system management strategies and practices in the context of good engineering practices and the core attributes important to managing and operating sanitary collection systems.

Section 2. Core Attribute Assessments

The American Public Works Association (APWA), American Society of Civil Engineers (ASCE), National Association of Clean Water Agencies (NACWA), and the Water Environment Federation (WEF) worked collaboratively to engage a broad group of industry stakeholders to identify and develop good engineering practices and core attributes essential to managing and operating sanitary collection systems. These organizations defined twelve fundamental principles that support effective collection system management.

These “Core Attributes of Effectively Managed Wastewater Collection Systems” are intended to provide guidance for wastewater collection system managers to evaluate their existing programs and confirm they are performing according to industry good engineering practices, and identify practices that are lacking or in need of enhancement. These attributes are not intended to be strict guidelines; the need for specific elements included in the attributes will vary between utilities based on size, organizational structure, performance history, and availability of resources.

This collection system assessment is organized around the following 12 core attributes:

- Core Attribute 1 – System Inventory and Information Management
- Core Attribute 2 – Maintenance Management System
- Core Attribute 3 – Safety and Training
- Core Attribute 4 – Overflow Emergency Response Plan
- Core Attribute 5 – Collection System Maintenance
- Core Attribute 6 – Source Control
- Core Attribute 7 – Structural Condition Assessment and Evaluation
- Core Attribute 8 – System Hydraulic Capacity Assessment, Evaluation, and Assurance
- Core Attribute 9 – Standard Design, Construction, and Inspection
- Core Attribute 10 – Communication and Outreach
- Core Attribute 11 – Monitoring, Measurement, and Modification
- Core Attribute 12 – Adequate Funding

These attributes were evaluated in the context of the priorities and level of service that the City wants to achieve, and regulators and the public expect. Level of service goals and priorities can vary significantly between utilities. During the IMP Visioning workshops, the City determined that the highest wastewater priorities that must be considered are maintaining public health protections, meeting level of service (LOS) goals, and providing justification for dedicated funding for certain activities. Specifically, the City would like to:

- Address wet-weather issues, including building backups, sanitary sewer overflows (SSOs), and areas with persistent inflow and infiltration (I/I) challenges;
- Eliminate hydraulic capacity limitations in the existing treatment and collection systems; and

- Develop and implement an asset management system to support system renewal and maintenance efforts and plan for future growth, including a mechanism to establish sufficient dedicated funding for these efforts.

Note that Core Attribute 10, Communication and Outreach, will not be addressed in this assessment of collection system activities, as the overall communication and outreach plan for the City will be addressed elsewhere in the Integrated Management Plan.

2.1 Core Attribute 1 – System Inventory & Information Management

Core Attribute 1 encompasses collection system inventory and information management. To efficiently manage the collection system, staff needs to be provided with sufficient resources to enable effective collection, storage, evaluation, and communication of data and information. Design, construction, and maintenance information needs to be readily available to meet a City's performance goals and system maintenance requirements. A comprehensive system inventory and information management system is an essential component to achieve efficient operations, and allows the City to plan and sequence future projects more efficiently.

Information management via geographic information system (GIS) software is a common platform used by many utilities. GIS can store, manage, analyze, and map spatially referenced system information. City maintenance management programs can also be integrated to GIS. An effective system inventory and information management system provides the following benefits to the City:

- Provides the necessary information to effectively respond to and prioritize service requests.
- Informs staff of existing system components and connectivity.
- Facilitates efficient system operation and maintenance.
- Builds confidence in analysis and decisions at the asset and system level.
- Minimizes risk of unforeseen service disruptions.
- Supports continuous system improvement.
- Generates consistent and reliable planning and forecasting information to improve management decisions.
- Supports system assessments and capital improvement planning.

The five main elements of system inventory and information management are:

- Asset identification and documentation;
- Data and process needs assessment;
- Information management plan development;
- Information management plan implementation; and
- Process monitoring adjustments.

Findings

The City has a dedicated GIS based information management system in place to handle its entire infrastructure. The collection system infrastructure is a component of the City-wide information system, but with its own unique data structure. A dedicated GIS team with a dedicated data administrator controls the GIS data, and coordinates additions and updates. In addition to its own staff, the City coordinates with Boone County, the Boone County Regional Sewer District, and the University of Missouri to update its database and keep it current.

The City has worked diligently to develop an extensive system inventory of the collection system. The spatial location and connectivity of all known pipes and structures are included in the Geographic Information System (GIS). Over 18,000 individual sanitary sewer pipes, with a total length of approximately 700 miles of gravity pipes and an additional 40 miles of forcemains for a total system length of 740 miles, are documented in the City's GIS (**Attachment A**).

Important asset attribute information such as pipe material, size, and installation date is available in GIS for much of the system. Invert information is also available for areas that have been surveyed, and areas where accurate as-built information is available. There are gaps present, particularly in invert elevation and pipe materials. The City should continue to work to fill in these data gaps. **Figure 1** and **Figure 2** present the collections system inventory by material for large diameter pipes, small diameter pipes, and all pipes, respectively.

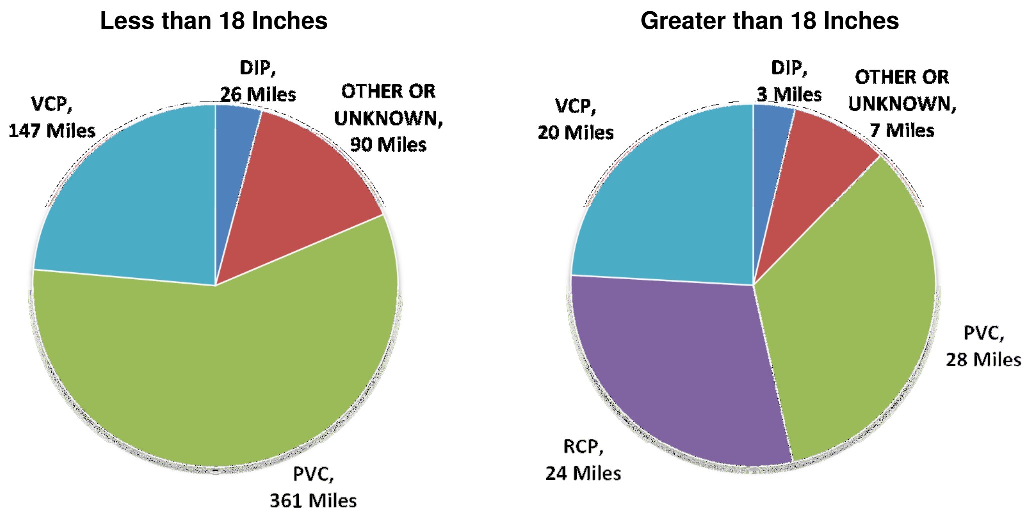

Figure 1. Inventory by Material for Gravity Pipes Less and Greater than 18 Inches in Diameter.

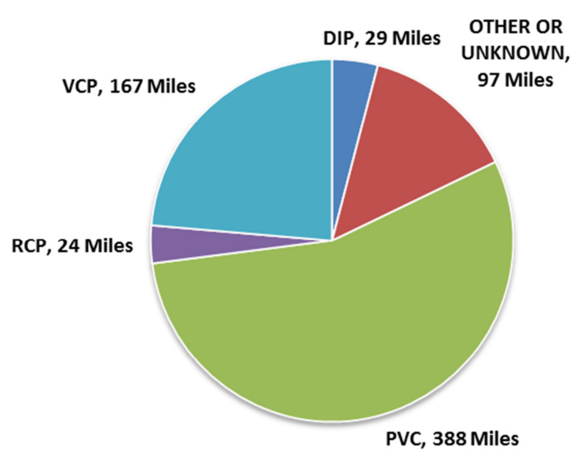

Figure 2. Inventory by Material for All Gravity Pipes.

The GIS database also contained the installation date for approximately 60% of the pipes. Missing pipe ages were estimated by HDR based off the age of adjacent infrastructure and subdivision platting. **Figure 3** presents a summary of the estimated age of the collection system. A map of the collection system by age is presented in **Attachment B**.

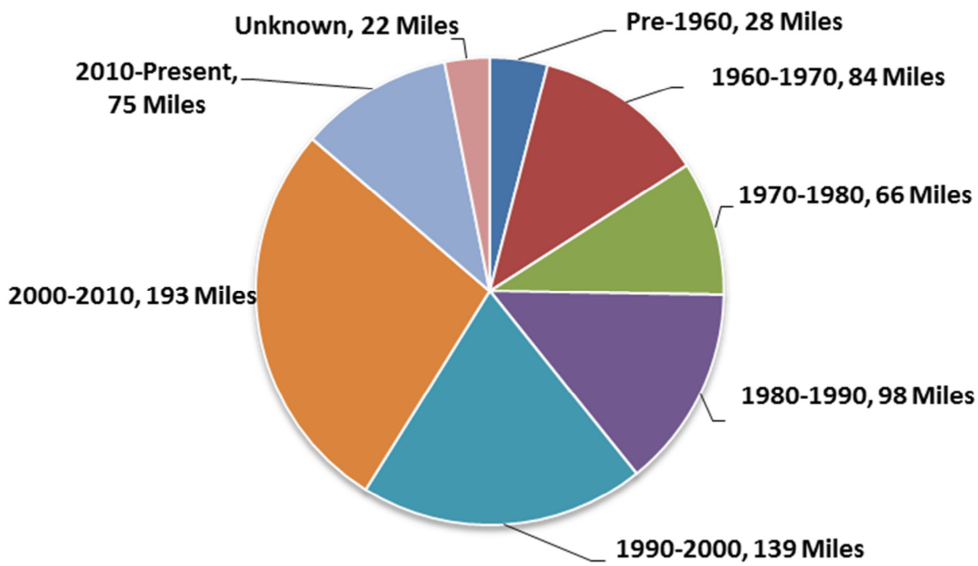

Figure 3. Estimated Collection System Age by Decade.

The City also uses their GIS system to document and track past and ongoing work activities, including the following:

- Work history from past and current sanitary sewer evaluation survey (SSES) projects - flow monitoring locations, public and private inflow and infiltration (I/I) source inspection results, and I/I source disconnection records.
- Capital project status tracking, including those projects which are planned, under construction, and complete.
- Maintenance records, which are updated nightly and include information such as date of pipe cleaning, cleaning findings identified by the field crew, and other observations like manhole conditions.
- Closed circuit television (CCTV) – indicator that identified which pipes have been inspected. Inspection findings and videos are not yet linked.

A thin client version of GIS on tablets is used by City staff to update data in the field. A backup and data synch takes place when the trucks return at the end of the day. Data is reviewed by the supervisor for anomalies and then backed up to the server. Asset data is also integrated on a nightly basis from the Boone County Assessor and cross checked for accuracy. New lines or infrastructure is updated by the inspectors handling inspections. This allows for efficient updating of the GIS to reflect changes identified by field staff, and to consistently track the status of work activities such as pipe cleaning.

Data related to complaints such as sanitary sewer overflows (SSOs), building backups and other infrastructure damage is recorded by the complaint receiving official or the inspector on a local database. A GIS layer is maintained showing historical backup and overflow locations. Separate data layers of infrastructure are also maintained and updated by consultants who monitor the system for condition and I/I. Following any type of work on the system, the system is updated by the City staff.

Management of the information collected by CCTV inspection crews was a gap identified during the assessment. The inspection crews use Granite XP software to record observations made during CCTV inspections. This data is not currently linked to the City's GIS, and the inspection observation database is not readily available for use by engineering and operations staff.

Recommendations

The City is in the process of developing a system inventory and information management system that effectively supports collection system management. The City has a dedicated GIS team in place and an effective system for updating the information systems, and continues to proactively improve their system inventory as information becomes available. Recent improvements such as tracking cleaning status and findings by pipe will enable the City to more effectively use the data collected by field crews to drive management decisions. The City should continue their efforts to integrate the system inventory and work order information management system.

Opportunities for improvement exist in the management of CCTV inspection data, which the City is currently working to improve. Integrating the CCTV observations with the information management system will make the inspection observation database readily available for use by engineering and operations staff. At the pipe and manhole level, this will enable the City to more efficiently make renewal and repair decisions. From a collection system management perspective, it will facilitate the use of condition assessment information to better allow for data driven forecasting of short and long term renewal and maintenance needs, and inform overall management strategies.

2.2 Core Attribute 2 – Maintenance Management System (MMS)

Core Attribute 2 is the practice of keeping a continuous record of maintenance activities to track system performance, optimize maintenance, and identify areas requiring frequent attention. An integrated maintenance management system (i.e., a system that ties to GIS mapping and other programs used to manage the collection system) not only ensures records are current, but also increases the efficiency of work in the field by allowing collection system staff to view current mapping and system inventory, maintenance history, and work orders. An effective maintenance management system provides the following benefits to the City:

- Uses defined pathway(s) assigning customer comments and complaints to the appropriate staff for timely response.
- Issues maintenance, repair, and inspection work orders to appropriate staff.
- Compares maintenance performance against City targets for key measures.
- Tracks maintenance and repair costs by specific assets or asset groups.

The three main elements of a MMS are software, maps of the collection system, and maintenance records.

Findings

The City does not currently have an integrated MMS. The City uses their GIS system to document and track past and ongoing work activities. Since the MMS is not integrated with the GIS, it requires some manual processes to link information from the collection system program activities such as cleaning. An integrated MMS designed for the City's utility would reduce these manual processes and further improve data flow and sharing for other activities, such as CCTV inspections.

Although an integrated MMS would offer advantages to the City, it is not entirely necessary for effective collection system management, and the need for a MMS varies based on the size of the utility and the state of existing processes. The City has a sufficient GIS mapping system, and a process in place for documenting maintenance records. The City has also developed processes that use their current systems to achieve some similar outcomes that a MMS would provide, such as linking cleaning work order documentation and findings to individual GIS assets like pipes.

Recommendations

The results of the assessment indicate that an integrated MMS is not a high priority item at this time, and overall the City is currently managing their collection system maintenance, repair, and inspection activities effectively without an MMS. As the collection system continues to grow and management needs change, the City may want to further evaluate the benefits of implementing an MMS.

2.3 Core Attribute 3 – Safety and Training

Given the hazardous nature and location of work, safety of the crew is of prime importance in the drive to efficiently manage a collection system. Exposure to hazardous structures, materials, atmospheres, vehicular traffic and chemical and biological contaminants makes the collection system maintenance job site a high priority for implementing safety. Well drafted training programs combined with safety guidelines and procedures can thwart accidents and keep the crew and the collection system safe and running. Hazard communication for understanding hazards that may be encountered while on job is critical to the health and safety of the worker. The four main elements of safety and training are hazard communication, safety training, staff development needs and adequate workforce resources. Benefits of a safety and training program include, but are not limited to, the following:

- Reduced insurance premiums,
- Increased productivity,
- Reduced time lost in accidents,
- Better regulatory compliance, and
- More knowledgeable workforce.

This assessment evaluated whether the City has implemented a safety and training program for collection system personnel in the context of effective collection system management. Evaluation of the specific health and safety practices included in the City's program is outside the scope of this assessment.

Findings

The focus on safety by the sanitary sewer maintenance division of the City is apparent from their mission statement which reads,"Keep the wastewater confined to the system in a SAFE and efficient manner". The Sewer Maintenance Division has a well written operation manual guidance document (Sorrell 2015) in place which it is apparent the crews abide by and follow when responding to complaints, performing regular system maintenance, or regular inspections.

Clear guidance is in place even for simple procedures such as removing manhole covers on a routine monitoring outing. Detailed descriptions, along with informative pictures on safety procedures, on complex work such as trenching and excavating is clearly documented in the operations manual (Sorrell 2015). The Maintenance Division requires mandatory confined space entry training, heavy equipment operations training, and driver's certification by operators who perform the work. A hazard communication program is also in place and strictly adhered to by staff. All activities and outings are clearly recorded and the appropriate personnel are notified in the event of mishaps. The City has provided the necessary health and safety gear and personal protective equipment to the maintenance crews. The City requires regular training and updates and gear checkup for the crew and gear, respectively.

The effectiveness of the City's detailed safety and training program is evident in the numerous Safety Awards regularly received by the Collection System, which is given out by the Missouri Water and Environment Association. The division has won the safety award 9 times (1993, 1996, 1997, 2001, 2002, 2006, 2008, 2012 and 2013) for 'Large Facilities' in the past two decades, which indicates an exemplary safety record (**Figure 4**).

Figure 4. Recent Collection System Safety Award Received by the City of Columbia.

Recommendations

Given their record in receiving safety awards, the City appears to have well established procedures and guidance in place. Our evaluation of their health and safety guidelines only reiterates their commitment to ensure the safety of everyone involved. The City should continue these efforts, and regularly evaluate their resources and training needed to continue their strong track record in safety.

2.4 Core Attribute 4 – Overflow Emergency Response Plan (OERP)

Core Attribute 4 is the development and implementation of an effective OERP. Implementing advanced response preparations for SSO events is crucial to managing the collection system to protect human and environmental health. An effective OERP provides several benefits to a wastewater utility, including:

- Enhancing the protection of public health and the environment;
- Providing compliance with regulations and permits;
- Maintaining trust with the public and regulatory agencies; and
- Minimizing the City's exposure and liability from claims, enforcement, or litigation.

The elements of an effective OERP are planning, notification procedures, documentation of the procedures for response planning and training purposes, and resource preparedness (e.g. ensuring essential parts, equipment, and contracting mechanisms are readily available).

Findings

The City has implemented an OERP. The OERP is updated by the City when needed; the most recent update to the plan was on November 30, 2015. The City OERP includes detailed procedures for responding to overflows. The OERP includes the following procedures:

- Notification procedures, with cell phone and home phone numbers for City staff who direct overflow responses.
- Notification of residents affected by the overflow, as warranted.
- Implementing a plan to effectively alleviate a dry weather overflow caused by a blockage or sewer failure.
- Securing the area to prevent unauthorized access to protect the public.
- Posting signs at any water body affected by the overflow, warning users of potential health risks.
- Procedures for containing the overflow, properly disposing of sewage when possible, disinfecting and deodorizing the area, and aeration of effected bodies of water if severe oxygen depletion is expected.
- Procedures for proper documentation of the overflow, including extent, location, cause, and discharge location.
- Proper notification of public agencies such as the Missouri Department of Natural Resources (MDNR) and Columbia/Boone County Public Health and Human Services.
- Proper materials on hand to complete repairs in pipes up to 30-inches in diameter and contract mechanisms in place to complete emergency repairs on larger diameter pipes.

Based on interviews with staff, the City has a record of successfully following the procedures laid out in the OERP.

Recommendations

The City's OERP appears to encompass the key elements of an effective plan, and has been successfully implemented. There are no recommended changes at this time.

2.5 Core Attribute 5 – Collection System Maintenance

Core Attribute 5 is focused on effective collection system maintenance, which is primarily achieved through the cleaning program. Proper system maintenance is vital to achieving safe conveyance of wastewater to the treatment plant, and avoiding backups or SSOs resulting from the accumulation of roots, grease, and debris in pipes. An effective collections system maintenance program provides many benefits to a City's wastewater utility:

- Averts or minimizes public health and environmental impacts.
- Reduces backups and sewer overflows.
- Reduces collection system odor.
- Minimizes backup claims from residents.
- Optimizes resources and reduces overall operation and maintenance costs.
- Increases the service life of the facilities.
- Minimizes potential of and exposure to enforcement and third-party litigation.
- Enhances the image of the wastewater agency.
- Maximizes available system hydraulic capacity.

A collection system maintenance program best practice is to implement an asset management approach for scheduling and executing cleaning of the system. Type and level of maintenance needs vary based on system size and characteristics such as age and materials. The frequency and schedule of maintenance activities is an important element in the development of an effective maintenance program. Managers should develop a schedule to perform maintenance in a timely manner based on history, collection system performance, and other risk based criteria, if available.

An effective cleaning program is typically comprised of the following activities:

- Proactive Preventive Maintenance Program – Scheduled cleaning, typically scheduled at the sub-basin or basin level
- "Hot Spot" Cleaning Program – Scheduled, accelerated cleaning of specific pipes or locations within the system where grease, debris, or root growth is known to quickly accumulate. These known trouble areas are typically cleaned on a much shorter schedule to mitigate the risk of overflow or backups.
- Reactive Cleaning – Unscheduled cleaning that occurs in reaction to a customer complaint, or to support the CCTV inspection program (e.g. the CCTV camera identified a major blockage that may result in an overflow that needs cleaned, or when the camera cannot make it through a pipe due to a blockage).

Findings

The City currently has 3 cleaning trucks and crews dedicated to executing the cleaning programs:

- Proactive Preventive Maintenance Program – This program is executed by proactively cleaning lines on a regularly scheduled basis. Lines are cleaned by sub-basin, generally beginning at the upstream end which allows an individual cleaning crew to work in the same geographic area. This cleaning schedule reduces driving time and increases cleaning productivity. The routine cleaning or inspection frequency for lines in which an obstruction may result in a backup into a residence or business is intended to be a minimum of once every five years. The routine cleaning or inspection frequency for all other lines is intended to be a minimum of once every ten years. Lines that cannot be accessed, or are too large for the City to effectively clean are visually inspected within 5 years to verify there are no visual flow disruptions caused by blockages. The current cleaning schedule does not differentiate between material types.

- “Hot Spot” Program – The City keeps an updated list of more than 50 lines of concern that are cleaned on a 6-month basis to mitigate the risk of overflows and backups.
- Reactive Cleaning – The City regularly executes reactive cleaning in response to customer complaints, and to support the CCTV inspection crews. In recent years, the mileage of CCTV inspections has increased with the addition of another crew, which subsequently increased the volume of reactive cleaning needed to support the inspections. This reduces the resources of available for proactive cleaning.

The cleaning program has continually improved collection system performance since its implementation in the 1960’s. The success of a cleaning program is primarily measured through the number of dry weather overflows and backups. According to the City’s data, dry weather building backups and overflows caused by a blockage in the main line have decreased from an average of over 90 per 100 miles of pipe per year in the late 1960’s to 2 per year per 100 miles of pipe in the last 10 years. These trends are shown below in **Figure 5**, expressed as overflows and backups per 100 miles of pipe.

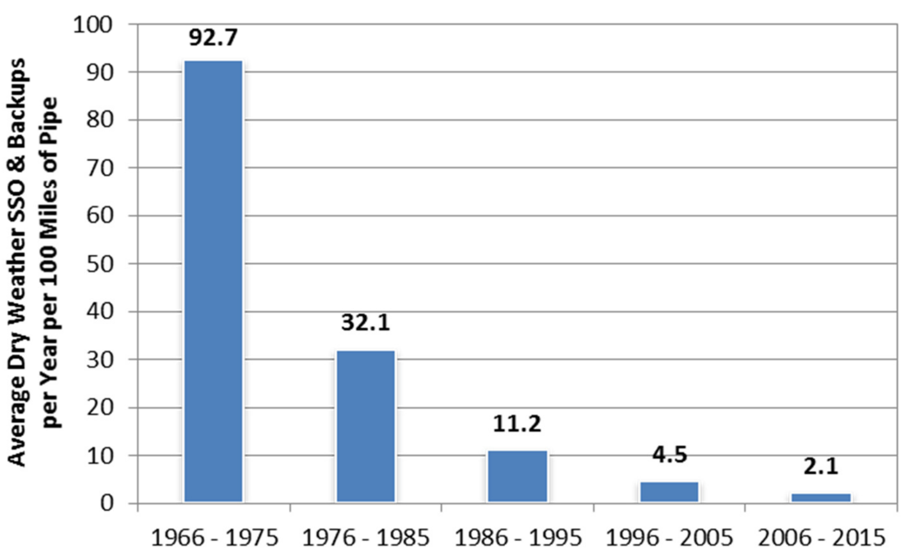

Figure 5. Historical Dry Weather Sewer Overflow and Backups in Columbia.

Performance has continued to improve in this area, and since 2010 the City has reduced this rate to an average of 10 per year, or less than 1.5 events per 100 miles of pipe (**Table 1 and Figure 6**). These results are in line with industry standards for an effective maintenance program.

Table 1. Recent Dry Weather Sewer Overflow and Backup Performance in Columbia.

Year	Dry Weather SSOs & Building Backups Per Year
2010	10
2011	10
2012	9
2013	6
2014	13
2015	12
Average	**10**

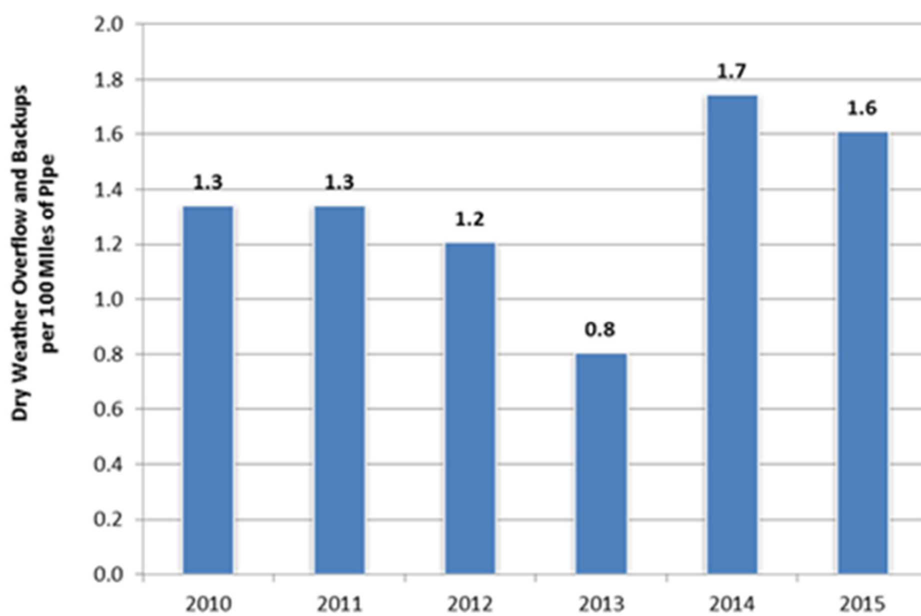

Figure 6. Dry Weather Sewer Overflow and Backups in Columbia between 2010 and 2015.

The City's productivity rates per crew have historically been strong. The City has historically been able to meet their preventive maintenance goals and have been able to clean lines approximately every four to five years. However, the City is facing challenges that are anticipated to make it harder to continue to meet proactive maintenance goals. These challenges include:

- According to the latest Census, Boone County is the fastest growing county in the state and Columbia is now the fourth largest city, which has resulted in continued growth of the collection system maintained by the City.
- In recent years, the City has increased the mileage of CCTV inspections in order to proactively assess the condition of the collection system and identify and mitigate structural issues and I/I sources. This increases the amount of reactive cleaning needed to support the CCTV crews, and decreases the resources available for proactive cleaning.
- The cleaning trucks have recently moved to a new dispatch facility at the WWTP, which has increased the driving time for the cleaning crews to much of the City.

Recommendations

In order to meet these challenges, optimize the use of resources, and continue the trend of improved performance, it is recommended the City build on the past successes and move towards implementing an asset management approach for scheduling and executing cleaning of the system. The program would focus on cleaning the right pipes at the right time, i.e. cleaning dirty pipes more often while cleaning clean pipes less often. Note that additional cleaning resources may also be required to meet these challenges.

To date, the City has been performing proactive cleaning of all accessible pipes (excluding those included in the “hot spot” program) on the same scheduled frequency. Typically, the level and frequency of maintenance needs within the collection system varies based on pipe characteristics such as age and material.

For example, Vitrified Clay Pipe (VCP), typically installed in most areas of the system prior to the 1980’s, is more prone to root growth through the joints. As a result, VCP pipe typically requires more frequent cleaning to address root growth. Many utilities set goals to clean the portions of the collection system made up primarily of VCP pipe every two to four years.

On the other hand, the Polyvinyl Chloride Pipe (PVC) typically installed in newer parts of town is not nearly as prone to root growth as VCP. It is also newer, and typically has less structural defects where debris may accumulate (e.g. offset joints). Many utilities clean this on a less frequent basis than VCP, often cleaning the newer areas of the system every six to eight years.

It is our experience that many cleaning frequencies that do not differentiate between materials often result in the City over-cleaning newer PVC pipes. The resources spent on cleaning this pipe would be more beneficially spent cleaning the older parts of town where root growth is a bigger issue.

Recent improvements to the City’s information system facilitate moving towards a data driven approach to cleaning scheduling. Mapping improvements provided by the GIS allow the City to identify the predominant age and materials of pipes in different areas of town, and facilitates the execution of cleaning work orders focused on cleaning specific areas of the system on different schedules. Additionally, the cleaning findings that have been recorded in GIS at the pipe level for the past two years will help to validate updated cleaning frequencies. An initial evaluation of the cleaning findings recorded by the City's cleaning crews was completed on approximately 10,000 pipes. The cleaning findings indicated that 78% of the pipes were believed to be clean at the time of cleaning (**Figure 7**). The areas where pipes are predominantly clean are typically newer parts of town comprised of PVC.

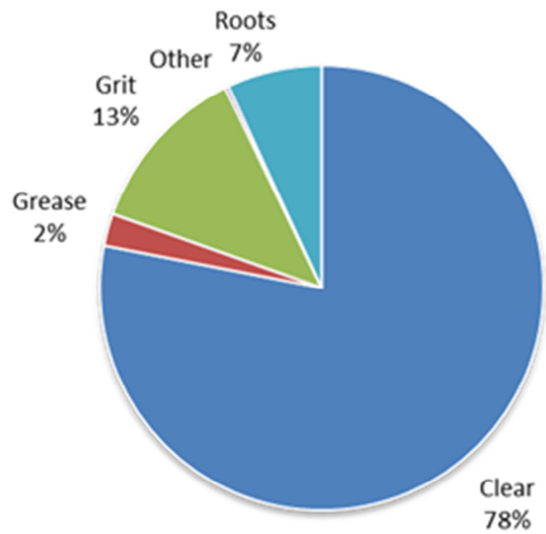

Figure 7. Summary of Cleaning Findings Documented through October 2016.

It is recommended that the City modify the cleaning findings recorded by their crews to better reflect the quantity of roots, grease, or debris present in the pipe at the time of the cleaning. The findings should differentiate between minor/moderate blockages and heavy blockages, because minor to moderate root growth typically means the pipe is being cleaned on the right schedule, while heavy root growth would indicate that the pipe may need to be cleaned more frequently. The findings recorded by crews should be simple and repeatable. In our experience, a 1 – 3 rating scale often works well and provides the actionable data needed to make decisions. An example scoring system for roots is shown below in **Table 2**.

Table 2. Example of a Scoring System that Could be Used to Establish Cleaning Findings.

	1 = Clean	**2 = Moderate**	**3 = Heavy**
Roots	***Visual:*** No evidence of roots, or small bits of hair/curtain roots without large clumps. **Passes:** 1 pass sufficient to clean. **Code: 1-Clean**	***Visual***: Moderate clumps of roots. Roots of 1/8" to 3/8" thickness. ***Feel***: Hose does not bind, or hydraulic pressure does not jump when roots encountered. **Passes:** Typically 1-2 passes sufficient to clean. **Code: R-2**	***Visual***: Large clumps of roots. Roots over 1/2" thickness. ***Feel***: Hose binds, jumps or slows down, hydraulic pressure can jump when using hydro cutter. **Passes:** Requires easing of saw into mass to remove roots. **Code: R-3**

This type of scoring system provides actionable data that can be used to inform management decisions. For example, if the findings for most pipes within a sub-basin were the following:

1 – Consider cleaning pipes less often

2 – Clean pipes on the same schedule

3 – Consider cleaning pipes more often

Note that CCTV data is another data source to use to aid in developing a data based refinement to cleaning frequencies. CCTV inspection findings can be evaluated in the context of the cleaning schedule to determine the rate of root growth, and the extent of other maintenance issues at both a pipe and sub-basin level. These findings can be used to inform cleaning schedule modifications.

All cleaning schedule modifications should be thoroughly reviewed with operations and engineering staff prior to implementation. The experience of cleaning crew leaders and other operations staff is an invaluable resource that should be fully used during schedule refinement. In order to maintain geographic centricity, in most cases cleaning schedules should be set so that all pipes within a sub-basin are cleaned on the same schedule (other than those pipes that are part of the “hot spot” program and thus cleaned on an accelerated schedule). This reduces driving time and increases productivity.

The City’s maintenance program has a demonstrated a strong trend of continuous improvement over the past several decades. The City has worked to reduce the rate of dry weather backups and overflows, and since 2010 the rate has averaged less than 1.5 events per year per 100 miles of pipe. Most similar regional utilities have goals ranging from less than 2 to less than 4 per 100 miles, with the stronger performing utilities typically maintaining average rates below 2 per 100 miles. The City’s results are in line with industry standards for an effective maintenance program.

In order to meet future challenges, optimize the use of resources, and to continue the trend of improved customer service, it is recommended the City build on these past successes and move towards implementing an asset management approach for scheduling and executing cleaning of the system. Additional cleaning resources may also be required to meet these challenges. This will be evaluated further during the Alternatives Analysis.

2.6 Core Attribute 6 – Source Control

Core Attribute 6 encompasses the preventative measures aimed at reducing potentially harmful discharges into the collections system that could cause blockages or overflows. Controlling these discharges improves collections system performance. An effective source control benefits the wastewater utilities by minimizing system overflows that result from blockage and minimizing system maintenance downstream of harmful discharge sources.

The five main elements of source control are:

- Fats, oils, and grease control (FOG program);
- Root control;
- Corrosion control;
- Vandalism prevention; and
- Odor prevention and control.

Findings

In the past, the City's collection system experienced many issues with grease blockages. To address this issue, the City implemented a dedicated FOG program approximately 15 years ago. The program employs a dedicated FOG inspector who regularly (six month schedule at the minimum) monitors grease traps and oil drains from known registered sources, such as restaurants and other commercial sources.

The FOG program has been successful and has helped lead to a considerable reduction in FOG related issues over the years. This success is reinforced by the fact the collection system has experienced an average of less than one overflow and backup per year caused by grease blockages.

The maintenance crew supervisors did note that they have observed a rise in residential sources for FOG in the recent years. A public education program will be discussed further and may be evaluated as part of the community outreach portion of the IMP. The City faces challenges in this area because a majority of its population is of a "rolling" type (e.g. college students). The City is considering a continuous education program focused on specific residential areas known to be sources of FOG.

The City addresses roots through the pipe cleaning program, as previously described in Core Attribute 5.

Corrosion is addressed on a case by case basis, when it occurs. It is recommended that the City pursue implementing additional measures on a case-by-case basis to protect infrastructure from corrosion due to hydrogen sulfide attacks, such as proactive epoxy lining of manholes that are located in the vicinity of forcemains or low pressure sewer discharges.

The City does not have any significant known problem locations for odor within the collection system. Odor control is typically addressed during the design of facilities that may cause odor issues.

Recommendations

The City has been successful in addressing source control to reduce unwanted discharges to the collection system. This is highlighted by the successful FOG program that has considerably reduced the quantity and extent of grease related blockages within the collection system. No changes are recommended to the FOG program at this time.

It is recommended that the City use engineering best practices to protect collection system facilities from corrosion, and provide odor control on a case-by-case basis, as warranted. The City should also consider efforts to educate the public on this issue through a continuous education program.

2.7 Core Attribute 7 – Structural Condition Assessment & Evaluation

Core attribute 7 is the structural condition assessment and evaluation of collection system pipes and manholes. Pipes and manholes deteriorate at different rates for many reasons. Condition assessment is a vital tool that allows utilities to identify and address deteriorated pipes before they collapse and cause a blockage that may result in an overflow or backup Proactive identification of structural deficiencies also allows utilities to address the infrastructure through cost-effective, trenchless rehabilitation techniques that minimize disruption to the public.

Condition assessment techniques vary based on material and accessibility. CCTV is the most popular and widely used industry method for pipe condition assessment. More specialized methods may be used when dictated by the situation, such as sonar scanning. An effective program uses inspection findings along with maintenance records, staff knowledge, and engineering judgment to prioritize and budget for short and long-term system renewal needs. This provides the following benefits to a wastewater utility:

- Reduces unexpected system failure, blockages, and overflows through preventation.
- Provides the information necessary to make informed decisions to plan and prioritize maintenance, rehabilitation and repair, and capital improvement projects.

Findings

The City's condition assessment activities consist primarily of the following:

- CCTV inspection of pipes to assess structural condition and potential for I/I.
- Manhole inspections to assess structural condition and potential for I/I.
- Exterior inspections of lines that may be at risk due to erosion, storm channels or other storm drainage paths, and exposed assets.

CCTV Inspection

The City has two CCTV trucks operating full time, primarily dedicated to condition assessment of the collection system. The trucks complete inspection of approximately 40 miles of sewer annually. Work performed by the crews on the CCTV trucks includes inspection of all new construction, including new or replaced service connections, prior to acceptance. Note that the City does not currently employ any contracted CCTV crews for proactive inspections but contractor crews do perform post-CCTV of Cured in Place Pipe (CIPP) lining. The primary inspection activities can be summarized as:

- Proactive inspections – proactive inspections, primarily in areas of the collection system with high I/I, or older areas of the system at higher risk of structural failure. These inspections are completed by sub-basin.
- Reactive inspections – inspections initiated to investigate a customer complaint, or in response to cleaning crews that are having issues cleaning lines.
- Repair acceptance – inspection of a recently completed pipe repair, completed to ensure the repair was completed successfully and in accordance with City standards.

The City has focused their inspection efforts on the highest risk areas of their system, and completed inspection of nearly all of the older VCP areas of the system that typically have higher rates of I/I and more prevalent structural issues. In HDR's experience, this puts the City ahead of the curve compared to many other peer utilities. Completing these proactive inspections of the older areas of the collection system is a collection system management best practice, and indicative of the focus that has been placed on maintaining and renewing aging collection system infrastructure. This proactive work will result in long-term savings for the City, and minimize disruption to the public by identifying structural issues that can be repaired though trenchless methods, before pipes fail, which often causes overflows/backups and requires expensive excavation to repair.

The inspection results have been evaluated and used as the basis for developing and executing the rehabilitation and repair (R&R) program. The City is currently CIPP lining approximately 30,000 feet of pipe each year, at about $2.7 Million annually, as well as completing point repairs with the in-house construction crew. This current system renewal rate equates to approximately 0.8% of the system renewed on an annual basis. The City's evaluation of the inspection data indicates a relatively high percentage of pipes inspected will require renewal to address structural or I/I defects.

The City has identified a backlog of over 700 pipes (approximately 31 miles of trenchless rehabilitation and over 150 pipes requiring various point repairs) that will be rehabilitated or repaired in the future, when the funding and/or staff resources are available. At the current renewal rate and funding levels, it will take the City several years to complete this backlog. This backlog estimate represents a snapshot in time of what the City has currently identified through its inspection program but does not reflect renewal needs for the entire collection system. As the City proactively inspects the collection system, additional needs will continue to be identified for the foreseeable future and a long-term, consistent funding source will be required to meet these needs. This is discussed further in this assessment in the context of Core Attribute 12, Adequate Funding.

Granite XP software is used for CCTV data collection. The City uses their own observation coding system, rather than using the more standard Pipeline Assessment and Certification Program (PACP) Coding. Although there are many advantages to using the standard PACP coding system, the end goal of any coding system is to provide the reviewer the information necessary to prioritize pipes for renewal and determine the optimum renewal method. Information includes:

- Type and severity of structural defects,
- Tap location and conditions,
- Infiltration and severity,
- Defect size and location,
- Maintenance defects (roots, grease, debris), and
- Percent blockage of the pipe.

A review of inspection records indicates the City's custom coding system meets the above requirements. As the current coding system is working effectively for the City, changing the current system at this time is not considered a high priority item. There are advantages to using the standard PACP coding system, and the City may consider transitioning at some point in the future when the timing makes sense. Note that most CCTV operators in the Midwest are trained to use the PACP coding system,

It was noted in Core Attribute 1 that management of the observation information collected by CCTV inspection crews was a gap identified during the assessment. The inspection results are not always readily available for use by engineering and operations staff for efficient analysis.

<u>Manholes Inspection</u>
The City completes proactive manhole inspections to identify structural issues and I/I sources. The primary internal inspection activities can be summarized as follows:

- Contracted manhole inspections in areas prone to high I/I.
- Yearly manhole inspections completed by in-house staff.
- Identification of major manhole issues observed by cleaning staff in the field.

The City has been aggressively assessing the condition of manholes through a combination of in-house and contracted inspections, and has also used their cleaning crews to document major manhole issues observed during cleaning activities. The City then completes rehabilitation and repair of defective manholes up to the available level of funding and in-house resources (funding levels will be addressed in the discussion of Core Attribute 12). These are all best practices, and another example of the City proactively assessing the condition of the collection system infrastructure.

<u>Exterior Inspection of Assets at Risk due to Erosion</u>
The City periodically inspects the following:

- Lines at risk to erosion that need to be checked periodically.
- Lines that need to be checked after heavy rains.
- Exposed lines that need to be checked annually.

These inspections, often called "stream crossing" inspections, are an industry best practice. Most inspection activities, such as CCTV inspection, are focused on the condition of the interior of the pipe, and do not address the effects of erosion and the forces caused by meandering stream channels and drainage ways. Regular inspection of these at risk lines to identify and mitigate these risks should be conducted. The City has an in-house program in place to assess these lines.

<u>**Recommendations**</u>

Opportunities for improvement exist in the management of CCTV inspection data, which the City is currently working to improve. Integrating the CCTV observations with the GIS system (and MMS system if the City implements one in the future) will enable the City to more efficiently make decisions at the asset level, and better allow for data driven forecasting of short and long term renewal needs for collection system management.

Integrating observations will also aid the City in prioritizing future CCTV and system renewal efforts. Currently, the City has a significant backlog of structurally deficient and leaky pipes that require rehabilitation. As the City continues to move forward with the inspection and rehabilitation of the collection system, using the data to inform an asset management based process for prioritization of inspection and renewal activities will help ensure the City focuses their resources where they provide the most benefit.

To sustain the level of service expected by the public, a dedicated long term funding source for infrastructure renewal is needed. The City's current source of renewal funding was enacted for a 5-year period through a bond issue, by public vote in 2013. A long term, consistent source of system renewal funding to replace the current funding is needed. This is discussed further in Core Attribute 12, Adequate Funding.

2.8 Core Attribute 8 – System Hydraulic Capacity Assessment, Evaluation, and Assurance

Core Attribute 8 involves the assessment of hydraulic collection system capacity and projected design flows, identification of capacity restraints, and planning to mitigate the capacity restraints.

A combination of flow monitoring, hydraulic modeling, and field investigation/verification is typically used to complete capacity assessment activities. The package or suite of resources used depends on the site and can vary throughout a collection system. Proper application allows a utility to characterize status throughout the system, identify system bottlenecks, predict future bottlenecks, strategically plan to reduce infiltration and inflow, quantify capacity requirements, and plan design, and implement corrective or preemptive action to maintain system performance. The benefits of system hydraulic capacity assessment evaluation, and assurance include the following:

- Protect public health and the environment by minimizing sewer backups and overflows.
- Delegate resources effectively to reduce planning, engineering, and operation and maintenance costs.
- Supports sound wastewater system, land-use planning, and development practices.
- Minimizes exposure to enforcement actions and third-part litigation.
- Confirms available hydraulic capacity to accommodate future growth.
- Assists in the management of system infiltration/inflow.

The three main elements of system hydraulic capacity assessment, evaluation, and assurance are:

- Flow monitoring
- Hydraulic modeling
- Field verification

<u>Findings</u>

During the IMP Visioning workshops, the City determined that the highest wastewater priorities that must be considered are maintaining public health protections, meeting level of service (LOS) goals, and providing justification for dedicated funding for certain activities. The City needs to address system capacity limitations and continue to reduce I/I in order to meet the following goals:

- Address wet-weather issues, including building backups, sanitary sewer overflows (SSOs), and areas with persistent inflow and infiltration (I/I) challenges;and
- Eliminate capacity limitations in the existing treatment and collection systems.

The annual totals of wet weather SSOs and backups and the rate per 100 miles of pipe are presented in **Figure 8**, respectively.

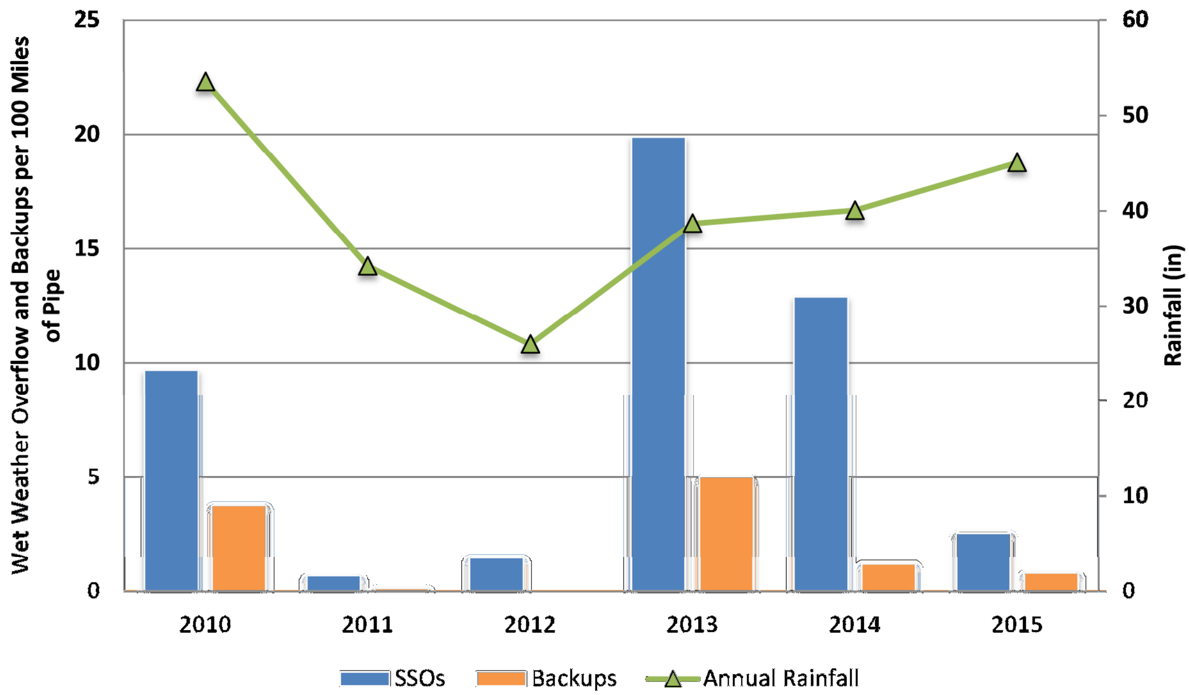

Figure 8. Total Number of Wet Weather Sanitary Sewer Overflows and Backups per 100 Miles of Pipes (2010 – 2015). Note that backup numbers are based on building backups that are reported to the City.

Addressing the performance of the collection system during major wet weather events was a primary objective identified during the IMP Visioning Workshops. Following ongoing issues with overflows and backups, the City has recently begun efforts to reduce overflows and basement backups through a combination of I/I reduction efforts and capacity improvement projects.

The City has identified the influent pump station to the wastewater treatment plant (WWTP) as a major capacity bottleneck that results in surcharging upstream through the collection system and can result in SSOs. The City completed operational improvements to the influent pump station near the end of 2014. These improvements increased pump station capacity and dramatically reduced surcharging and SSOs in the collection system upstream of the WWTP in 2015 (**Figure 8**). However, the influent pump station remains a bottleneck during major wet weather flow events. Alleviating this bottleneck should improve collection system performance and further reduce SSOs; however, additional improvements to the influent pump station would exceed the limits of the hydraulic capacity of the plant.

The City last conducted extensive flow monitoring and hydraulic modeling during development of the 2004 wastewater systems facilities planning efforts (B&V 2004). Flow monitoring and hydraulic modeling of specific areas has been completed in recent years; however, it has been primarily focused on those basins specifically targeted for I/I removal or specific capacity improvement projects. The flow monitoring data collected in 2003 is now considered to be out of date. The original hydraulic model was calibrated based off the 2003 flow monitoring results. At this point, City staff does not believe the hydraulic model is still an accurate representation of current collection system performance.

The City has an existing hydraulic model for portions of the collection system; however, it is primarily calibrated to the outdated flow monitoring, and its extent is limited to the primary interceptors within the collection system (**Figure 9**).

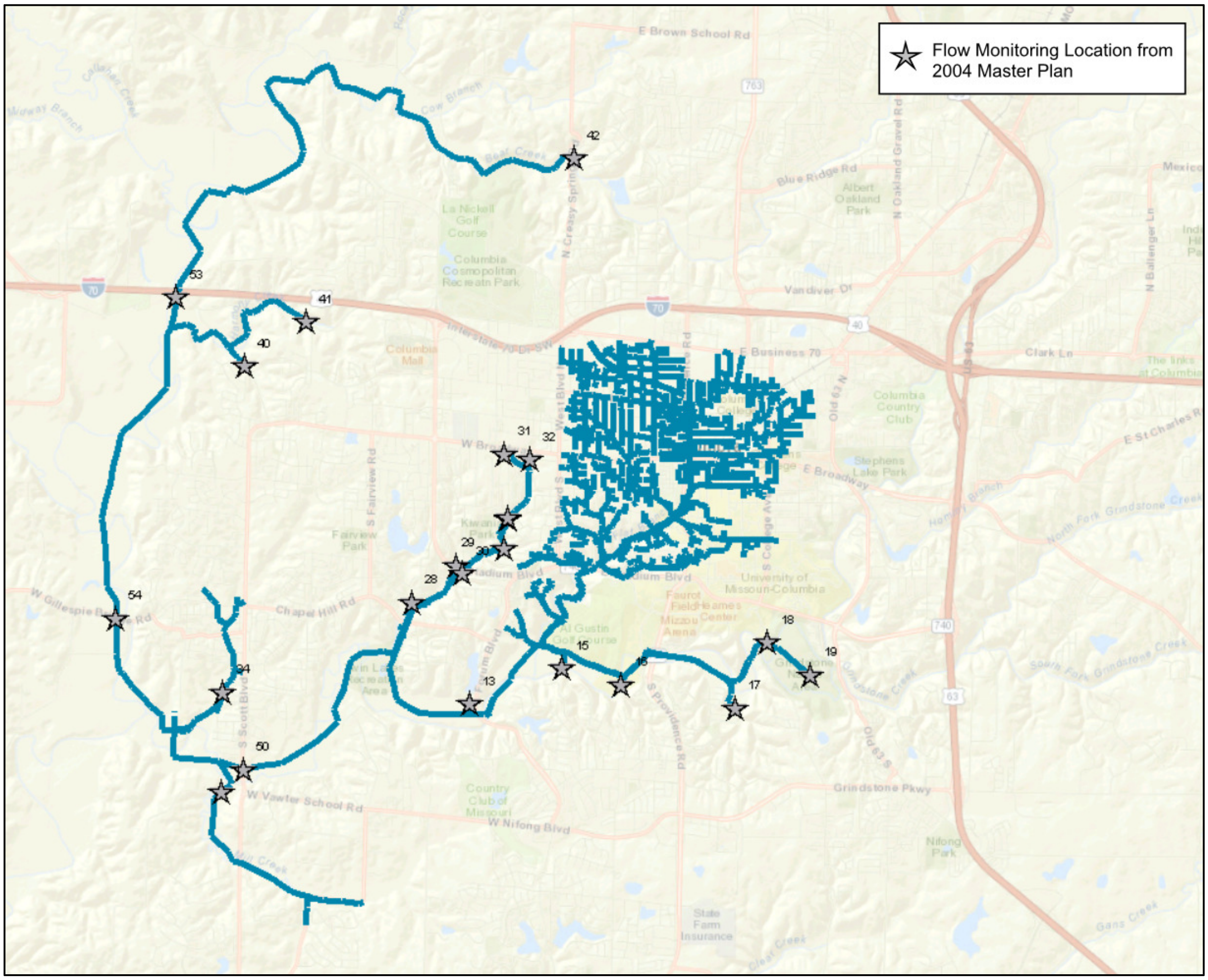

Figure 9. Extent of Existing Hydraulic Model.

Accurately identifying the current capacity constraints within the collection system is a primary concern for the City. There are capacity improvement projects identified in the 2004 wastewater systems facilities planning efforts (B&V 2004) and currently listed in the draft fiscal year (FY) 2017 capital improvements plan (CIP, Columbia 2016) that based on current conditions, may not be necessary. It is also believed that there are capacity bottlenecks within the system that are not identified 2004 wastewater systems facilities planning efforts (B&V 2004). An accurate hydraulic model, calibrated to current conditions through updated flow monitoring is necessary to identify the improvements needed and develop the plan for executing the improvements.

Note that the improvements will likely be a combination of I/I reduction and collection system capacity improvements.

Recommendations

In order to address the capacity issues present within the collection system, it is recommended that the City pursue the following activities over the next five years:

- Conduct flow monitoring to gather the data necessary to calibrate a hydraulic model of the collection system trunk lines (10-inch and larger).
- Collect survey data needed for key hydraulic model inputs.
- Develop and calibrate a hydraulic model of the collection system trunk lines using the City's current hydraulic modeling program, InfoSWMM.
- Develop simplified hydraulic modeling of small diameter lines within the collection system where the city believes capacity issues may be present (a spreadsheet model or simple hydraulic modeling program).
- Use hydraulic modeling to develop an improvements plan to identify and address capacity issues. Note that the improvements will likely be a combination of I/I reduction and collection system capacity improvements.
- Continue the City's current efforts to identify and address public sector I/I sources. Evaluate if private sector I/I reduction efforts should be expanded.
- Concurrently with these activities, evaluate alternatives to eliminate hydraulic capacity issues within the collection system, including improvements at the WWTP to alleviate the known bottleneck at the influent pump station. It is likely that peak flow storage facilities could be constructed to help alleviate this bottleneck.

2.9 Core Attribute 9 – Standard Design, Construction, & Inspection

Core Attribute 9 is a utility's best cost approach to provide reliable wastewater service through proper design, construction, and inspection procedures that meets the needs of the community and regulatory standards. Planning and design decisions are interwoven with short and long term strategies in order to bring a concept into reality. Facilities are built in the construction phases in accordance with current methods and materials. Inspection is integral to the construction phases in order to ensure facilities are properly built in accordance with plan and design. The benefits of standard design, construction, and inspection include the following:

- Supports public health and the environment through proper wastewater collection system and facilities.
- Supports the goals of the utility's management.
- Supports the ability of the utility to meet regulatory standards, and minimizes system infiltration and exfiltration.
- Maximizes the use of public money by providing the best facilities at the least cost.
- Reduces operations and maintenance costs over the service life of facilities.
- Maximizes service life of facilities.

The four main elements of standard design, construction, and inspection are planning, design, construction, and inspection. The City's current practices in these four areas are summarized below.

Findings

Planning

A systematic planning process is in place for capital improvement projects. Design flow criteria for new collection system facilities and upgrades to existing facilities are detailed in the 2004 wastewater systems facilities planning efforts (B&V 2004). The flow metering data collected during the planning efforts was used as the basis for this design flow criteria (note that the design flows produced using this criteria exceed MDNR minimum design criteria). New facilities are designed to carry peak flows for the 10-year storm event. The planning process takes into account future development as well as potential changes to land use within the service area.

Alternatives are thoroughly evaluated during the planning process. The cost-effectiveness analysis takes into account constructability, geotechnical conditions, easement acquisitions, and future conditions. Non-economic factors including environmental impacts and community disruptions are evaluated and factored into the alternatives analysis.

Design & Construction

The City has standard design criteria in place for typical collection system projects. The criteria include many industry best practices to ensure new facilities are constructed to acceptable standards. The criteria also include specific industry standard testing procedures to be followed during construction.

Capital improvements projects are typically administered through the standard Design-Bid-Build process. The bulk of construction administration activities for typical collection system projects are performed in-house. A term and supply contract is in place with a vendor for sewer rehabilitation work. This provides advantages to the City, as it saves time and money on engineering and administration time that would be required if the bidding process was followed for each rehabilitation authorization.

Inspection

All construction work is inspected. The majority of the inspection work for collection system projects is completed in-house. Additionally, the CCTV crews complete post-rehab acceptance CCTV of both in-house and contracted repair/rehabilitation work and new sewer extensions, to ensure repairs are acceptable.

Recommendations

The City's design, construction, and inspection programs are thorough and incorporate many industry best practices. The current processes have been effective for the City, and no modifications are recommended at this time.

2.10 Core Attribute 10 – Communication Outreach

The communication and outreach plan for the City will be addressed later during the integrated planning process. Therefore, Core Attribute 10 is not addressed in this assessment of collection system activities.

2.11 Core Attribute 11 – Monitoring, Measurement, and Modification

Core Attribute 11 involves the monitoring, measurement, and modification of collection system programs. Collection system managers should routinely track and evaluate system and program performance, and make necessary modifications and adjustments based on these results. These Key Performance Indicators (KPIs) are used to evaluate the utility's success in meeting strategic goals, quantify the benefits of continuous improvement initiatives, and measure performance in managing gravity sewer infrastructure.

The benefits of these practices include the following:

- Optimizes use of utility resources.
- Realizes performance gains with reasonable effort.
- Allows staff to report progress of system performance.
- Provides validation when an assessment plan is successful.
- Builds support and trust between staff and stakeholders.

The two main elements evaluated for the attribute are:

- Monitoring, measurement and modifications
- Performance measures – i.e. KPI's

Findings

Keeping the goals and objectives of the assessment plan current with community priorities and regulatory standards is essential. The City does not currently have a formal KPI plan. However, the City regularly tracks several important KPIs, including the following:

- Wet weather backups and SSOs (note: goals for this KPI are often tracked relative to the City's collection system design storm event criteria, e.g. no SSOs per year unless greater than a 10-year storm event occurs)
- Dry weather backups and SSOs
- Total service requests, and responsibility (public or private)
- Cleaning mileage (jetted and root-sawed)
- CCTV inspection mileage
- Customer service response time
- Monitoring effectiveness of I/I reduction efforts, where appropriate
- Sewer rehabilitation and repair
    - Trenchless (CIPP)
    - Replacement footage
    - Manhole repairs
    - Lateral connection repairs

When identifying key performance indicators to track, a particular emphasis should be placed on developing "actionable" KPIs that support the City in making business decisions, allocating resources, and identifying potential challenges that if unmitigated could negatively impact performance and service levels. It is typically most effective for a utility to track a relatively small number of actionable KPIs with meaningful goals that support decision making, rather than tracking a larger number of statistical KPIs that do not inform management decisions.

The City has made significant progress towards developing an actionable KPI plan, and is already collecting the key data needed to monitor collection system program progress. However, the City has not yet developed the goals needed to fully use this information and translate it to actionable KPIs that drive decisions. System performance goals should be developed and aligned with industry standards for effective collection system management. Maintenance and inspection productivity goals should be data-based and align with the practices needed to optimize maintenance activities. For example, system cleaning goals should be determined based off the cleaning mileage necessary to effectively clean the collection system (i.e. focusing cleaning activities on cleaning pipes at the right time), which may include cleaning older, VCP pipes that are prone to roots on a more frequent basis than newer PVC pipes that present less risk of backup due to blockages.

Recommendations

The City tracks several important KPIs that form a foundation for developing an actionable KPI plan that will support continuous improvement. It is recommended that the City take the next step and update the collection system goals to ensure they are in line with the City's short and long term collection system management goals. Achieving these goals should be measured through actionable KPI's that support the City in making business decisions, allocating resources, and identifying potential challenges that if unmitigated could negatively impact performance and service levels. Alternatives for these goals will be further analyzed and reviewed as part of the Alternatives Analysis.

2.12 Core Attribute 12 – Adequate Funding

Core Attribute 12 is focused on ensuring that adequate funding exists to provide the consistent revenue stream needed to support the effective management of the collection system. The benefits of a sustainable revenue stream and adequate funding include the following:

- Ensures adequate funding is available to provide the utility the necessary resources to achieve level of service goals.
- Increases system performance and achieves positive results.

The five main elements of adequate funding are rate structure characteristics, revenue requirements, cost of service, rate structure, and additional funding sources. The City recently conducted cost of service studies for the wastewater and stormwater utilities to set rates and a structure to adequately fund current programs. The IMP is being developed to help determine long term utility funding needs and establish the right prioritization of funds between the collection system, treatment facilities, and stormwater infrastructure. Therefore, the overall utility rate structure and revenue requirements were not evaluated specifically in the context of the collection system program needs. However, over the course of the assessment, potential future funding gaps have been identified that could negatively impact the City's ability to effectively manage the collection system.

Findings

The City owns and operates approximately 700 miles of gravity sewer lines. The replacement costs for these pipes and manholes were estimated to be approximately $700 Million. This high level estimate was based on the system inventory in the City's GIS and typical replacement costs from the Midwestern region.

The City's current source of renewal funding was enacted through a publicly-approved bond issue. The bond issue established funding for a five year period. This funding is primarily focused on rehabilitation of public infrastructure in areas that experience high I/I. This annual budget of $2.7 Million is available through 2019, at which point a new funding source will need to be secured.

It was noted in Core Attribute 7 that the City has already identified a backlog of over 700 pipes that will require trenchless rehabilitation or other repairs to address I/I or structural deficiencies. At the current funding level, this represents an existing backlog of more than three years of system renewal work on pipes alone (this figure does not included manholes or forcemains). This backlog estimate represents a snapshot in time of what the City has currently identified through its inspection program. However, this backlog does not reflect renewal needs for the entire collection system. As the City proactively inspects the collection system, additional needs will continue to be identified for the foreseeable future and a long-term, consistent funding source will be required to meet these needs.

If not addressed, as this infrastructure continues to age and deteriorate, failure rates could increase resulting in overflows and building backups. Expensive emergency repairs that are disruptive to the community could also increase. To sustain the level of service expected by the public, a consistent long term funding source for infrastructure renewal is needed.

Recommendations

To sustain the level of service expected by the public, a consistent long term funding source for infrastructure renewal is needed. As the City continues to work towards implementing an asset management approach to support system renewal and maintenance efforts, the magnitude of these needs will be defined more clearly. Implementing a mechanism to establish sufficient dedicated funding for the City's future needs is one of the primary goals. Alternatives to achieve these goals will be further analyzed and reviewed as part of the Alternatives Analysis.

There are capacity improvement projects included in the future Capital Improvements Plan CIP, identified through the 2004 Wastewater Facilities Planning Report that staff believe may not be necessary. As detailed in Core Attribute 8, it is recommended that the City develop an updated hydraulic model, in order to increase the level of confidence in the capital improvement projects and I/I reduction efforts needed to address SSOs and building backups within the collection system.

Section 3 - Summary of Recommendations

This section presents a summary of the recommendations detailed in Section 2. Refer to Section 2 for a detailed description of each attribute, the assessment findings, and recommendations.

Core Attribute 1 – System Inventory & Information Management: The City should continue their efforts to integrate the system inventory and work order information management system. Opportunities for improvement exist in the management of CCTV inspection data. Integrating the CCTV observations with the information management system will make the inspection observation database readily available for use by engineering and operations staff.

Core Attribute 2 – Maintenance Management System: Although an integrated MMS would offer advantages to the City, it is not necessary for effective collection system management, and the need for a MMS varies based on the size of the utility and the state of existing processes. An integrated MMS is not a high priority item at this time, and overall the City is currently managing their collection system maintenance, repair, and inspection activities effectively without an MMS.

Core Attribute 3 – Safety and Training: The City has a detailed safety and training program, and has received the Collection System safety award from the State Water and Environment Association nine times in the past two decades. The City should continue these efforts, and regularly evaluate their resources and training needed to continue their strong track record in safety.

Core Attribute 4 – Overflow Emergency Response Plan: The City's Overflow Emergency Response Plan appears to encompass the key elements of an effective plan, and has been successfully implemented. There are no recommended changes at this time.

Core Attribute 5 – Collection System Maintenance: The cleaning program has continually improved collection system performance since its implementation in the 1960's. The success of a cleaning program is primarily measured through the number of dry weather overflows and backups. These results are in line with industry standards for an effective maintenance program. The City's productivity rates per crew have also been strong, and the City has historically been able to meet their preventive maintenance goals and clean lines approximately every four years. However, the City is facing challenges that are anticipated to make it harder to continue to meet proactive maintenance goals and provide the LOS the City hopes to achieve.

In order to meet current and future challenges, optimize the use of resources, and to continue the City's trend of improved customer service, it is recommended the City build on the past successes and move towards implementing an asset management approach for scheduling and executing cleaning of the system. The program would focus on cleaning the right pipes at the right time (i.e. cleaning dirty pipes more often while cleaning clean pipes less often) in order to most effectively use the City's resources.

Core Attribute 6 – Source Control: In the past, the City's collection system experienced many issues with grease blockages. To address this issue, the City implemented a dedicated Fats, Oils, and Grease (FOG) program approximately 15 years ago to address grease blockages within the collection system. The FOG program has helped considerably reduce the quantity and extent of these blockages. No changes are recommended to the FOG program at this time.

It is recommended that the City use engineering best practices to protect collection system facilities from corrosion, and provide odor control on a case by case basis, as warranted.

Core Attribute 7 – Structural Condition Assessment and Evaluation: Opportunities for improvement exist in the management of CCTV inspection data. Integrating the CCTV observations with the information management system will enable the City to more efficiently make decisions at the asset level, and better allow for data driven forecasting of short and long term renewal needs for collection system management. This will also aid the City in prioritizing future CCTV and system renewal efforts. Currently, the City has a significant backlog of structurally deficient and leaky pipes that require rehabilitation. As the City continues to move forward with the inspection and rehabilitation of the collection system, using the data to inform an asset management based process for prioritization of inspection and renewal activities will help ensure the City focuses their resources where they provide the most benefit.

This current system renewal rate equates to approximately 0.8% of the system renewed on an annual basis. The City has identified a backlog of over 700 pipes that will be rehabilitated or repaired in the future, when the funding and/or staff resources are available. At the current renewal rate and funding levels, it will take the City several years to complete this backlog. As the City proactively inspects the collection system, additional needs will continue to be identified for the foreseeable future. The City's current source of renewal funding was enacted for a 5-year period through a bond issue. A long term, consistent source of system renewal funding to replace the current funding source is needed.

Core Attribute 8 – System Hydraulic Capacity Assessment, Evaluation, and Assurance: The City needs to address system capacity limitations and continue to reduce I/I in order to meet the goals identified in the IMP Visioning workshops. In order to meet these goals, it is recommended that the City pursue the following activities over the next five years:

- Conduct flow monitoring to gather the data necessary to calibrate a hydraulic model of the collection system trunk lines (10-inch and larger).
- Collect survey data needed for hydraulic modeling.
- Develop and calibrate a hydraulic model of the collection system trunk lines using InfoSWMM or another high quality hydraulic modeling program.
- Develop simplified hydraulic modeling of small diameter lines within the collection system where the city believes capacity issues may be present (a spreadsheet model or simple hydraulic modeling program).
- Use hydraulic modeling to develop an improvements plan to address the capacity issues. Note that the improvements will likely be a combination of I/I reduction and collection system capacity improvements.

- Concurrently with these activities, evaluate alternatives to eliminate hydraulic capacity issues within the collection system, including improvements at the WWTP to alleviate the known bottleneck at the influent pump station. It is likely that peak flow storage facilities could be constructed to help alleviate this bottleneck.

Core Attribute 9 – Standard Design, Construction, and Inspection: The City's design, construction, and inspection programs are thorough and incorporate many industry best practices. The current processes have been effective for the City, and no modifications are recommended at this time.

Core Attribute 11 – Monitoring, Measurement, and Modification: The City tracks several important Key Performance Indicators (KPIs) that form a foundation for developing a KPI plan that will support continuous improvement. It is recommended that the City take the next step and update the collection system goals to ensure they are in line with the City's short and long term collection system management goals. Achieving these goals should be measured through actionable KPI's that support the City in making business decisions, allocating resources, and identifying potential challenges that if unmitigated could negatively impact performance and service levels. Alternatives for these goals will be further analyzed and reviewed as part of the Alternatives Analysis.

Core Attribute 12 – Adequate Funding: The City's current source of renewal funding was enacted through a publicly-approved bond issue. The bond issue established funding for a five year period. This funding is primarily focused on rehabilitation of public infrastructure in areas that experience high I/I. This annual budget of $2.7 Million is available through 2019, at which point a new funding source will need to be secured.

The City has already identified a backlog of over 700 pipes that will require trenchless rehabilitation or other repairs to address I/I or structural deficiencies. At the current funding level, this represents an existing backlog of more than three years of system renewal work on pipes alone (this figure does not included manholes or forcemains). This backlog estimate represents a snapshot in time of what the City has currently identified through its inspection program. However, this backlog does not reflect renewal needs for the entire collection system. As the City proactively inspects the collection system, additional needs will continue to be identified for the foreseeable future and a long-term, consistent funding source will be required to meet these needs. To sustain the level of service expected by the public, a consistent long term funding source for infrastructure renewal is needed.

There are capacity improvement projects included in the future Capital Improvements Plan CIP, identified through the 2004 Wastewater Facilities Planning Report that staff believe may not be necessary. As detailed above, it is recommended that the City develop an updated hydraulic model, in order to increase the level of confidence in the capital improvement projects and I/I reduction efforts needed to address SSOs and building backups within the collection system.

Section 4 - References

Black and Veatch (B&V). 2004. Columbia Sanitary Sewer Utility Facilities Planning Report. Kansas City, MO. BV Project No. 132200.

City of Columbia (Columbia). 2016. FY 2017 Draft CIP Planning Document. Finance Department – Accounting Division. Columbia, MO. March 2, 2016. https://www.como.gov/finance/wp-content/uploads/sites/21/2015/11/FY-2017-Draft-Document-March-2016-1.pdf

Sorrell, David A. 2015. Operations Manual: Sanitary Sewer Maintenance. Utilities Department – Sewer Utility. Columbia, Missouri.

Stoner, N. and C. Giles. 2012. Integrated Municipal Stormwater and Wastewater Planning Approach Framework. June 5, 2012. Washington DC.

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Technical Memorandum 2

Attachments

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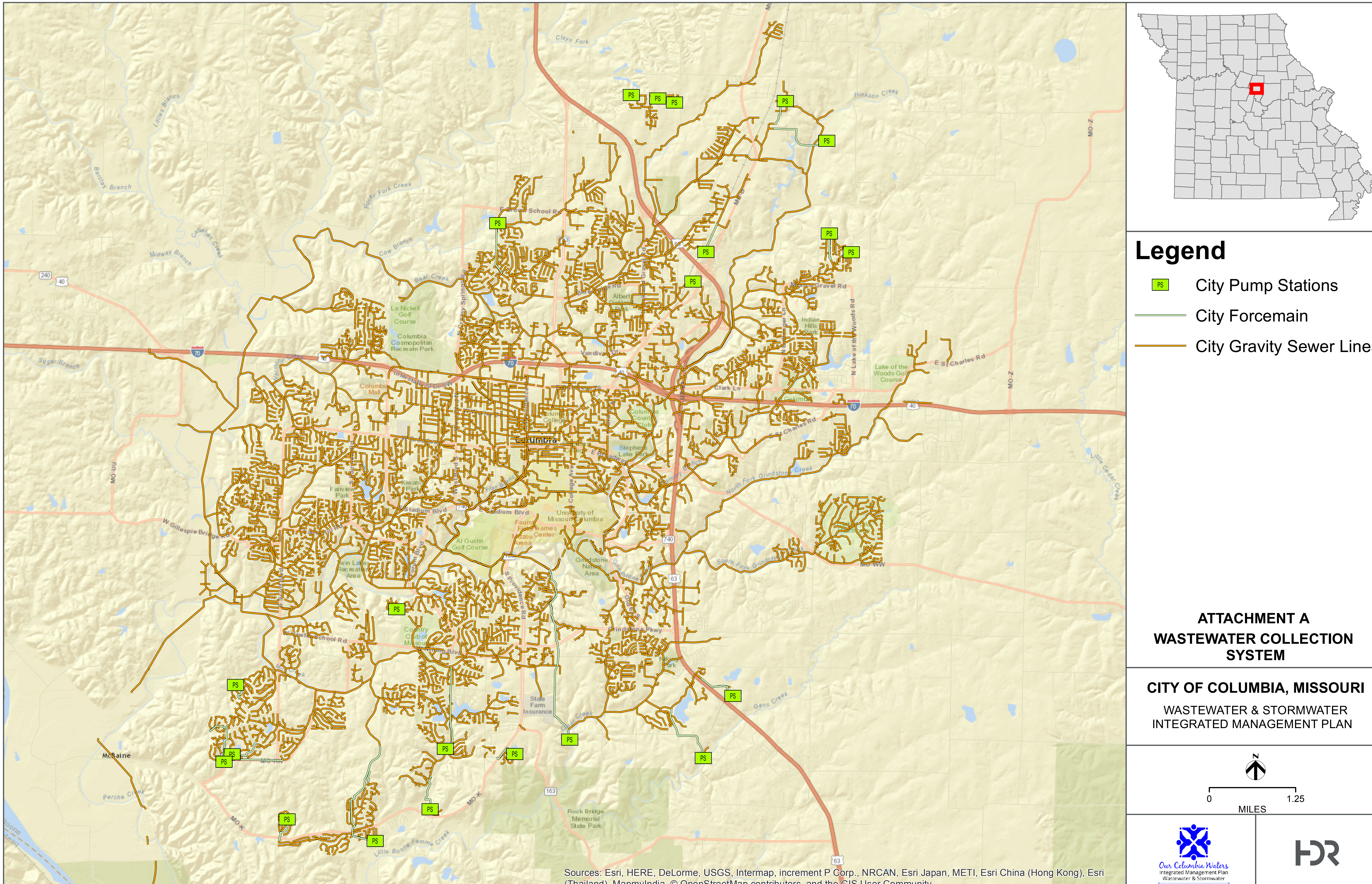
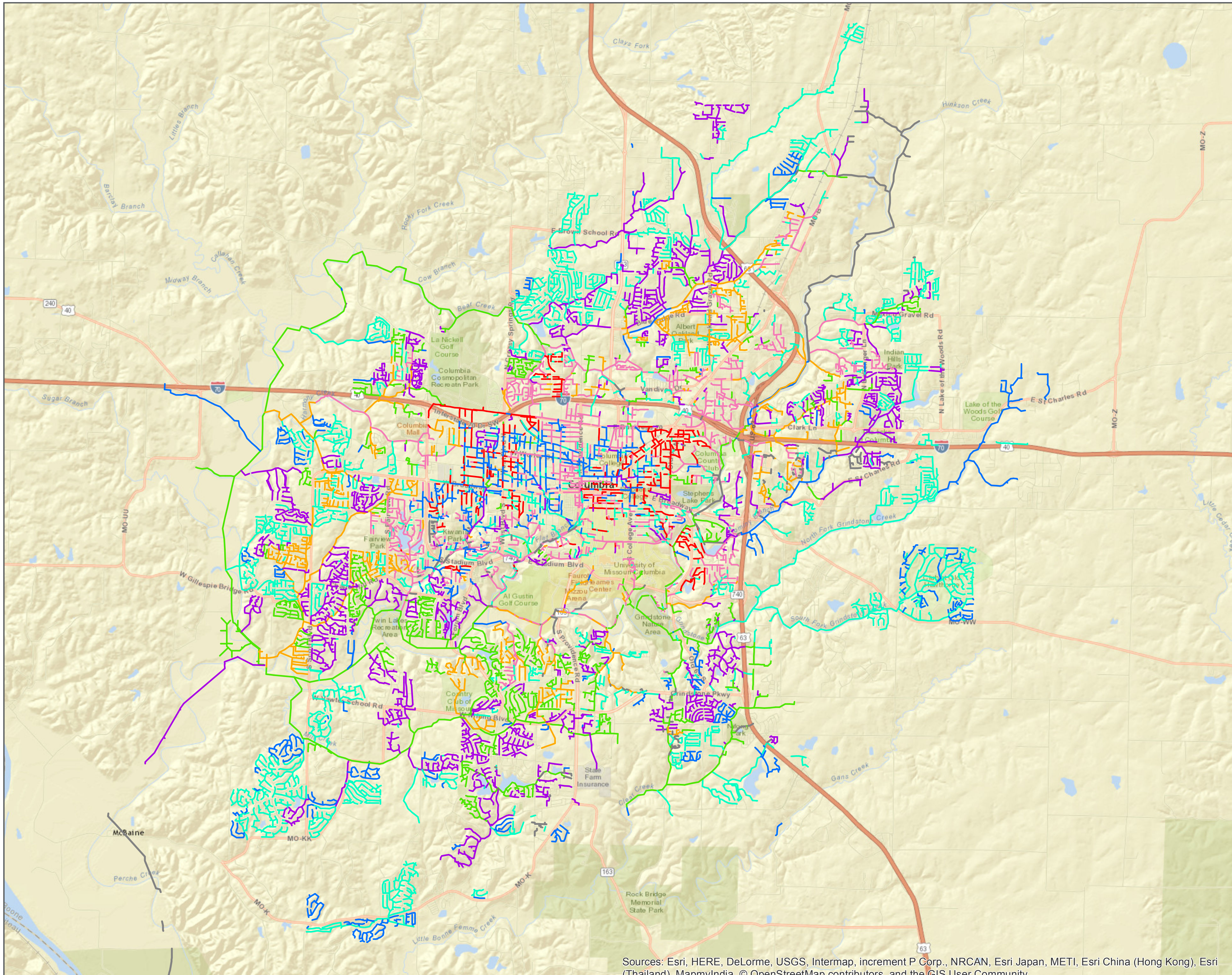


ATTACHMENT A
WASTEWATER COLLECTION SYSTEM

CITY OF COLUMBIA, MISSOURI

WASTEWATER & STORMWATER
INTEGRATED MANAGEMENT PLAN

Date: 9/21/2016



Legend

Pipe Without Age Data

DECADE

- Pre-1960
- 1960-1969
- 1970-1979
- 1980-1989
- 1990-1999
- 2000-2009
- 2010-Present

ATTACHMENT B
PIPE AGE BY DECADE

CITY OF COLUMBIA, MISSOURI

WASTEWATER & STORMWATER
INTEGRATED MANAGEMENT PLAN

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Our Columbia Waters
Integrated Management Plan
Wastewater & Stormwater

HDR

Date: 9/21/2016

Columbia Wastewater and Stormwater IMP

Attachment G

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Our Columbia Waters
Integrated Management Plan
Wastewater & Stormwater

Technical Memorandum 3
Wastewater Treatment System Evaluation

Columbia Wastewater and Stormwater Integrated Management Plan

Columbia, Missouri
February 2, 2017

HDR

Geosyntec consultants
Shockey Consulting Services, llc
TREKK DESIGN GROUP, LLC

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Section 1. Introduction and Objectives

The City of Columbia, Missouri (City) is working to develop an Integrated Management Plan (IMP) for the City's wastewater and stormwater utilities. The goal of the IMP is to develop an adaptable and affordable long-term plan that addresses the City's wastewater and stormwater management needs and meets Clean Water Act requirements. The IMP will be developed based on guidance presented in US Environmental Protection Agency's (EPA) *Integrated Municipal Stormwater and Wastewater Planning Approach Framework*[1].

A critical step in the IMP includes evaluating the City's environmental resources and infrastructure assets to better define the existing condition, performance, and needs of its systems. This evaluation is important because it forms the basis for identifying priorities and developing alternatives in subsequent phases of the IMP. To develop a comprehensive understanding of existing conditions, the City and their project team compiled and evaluated existing surface water, wastewater, and stormwater data. These data, as well as current operation and maintenance practices and procedures, were then reviewed and discussed in a series of workshops. Results from these efforts are documented in the following technical memoranda:

- Technical Memorandum 1 – Surface Water Quality and Biological Conditions
- Technical Memroandum 2 – Wastewater Collection System Assessment
- Technical Memorandum 3 – Wastewater Treatment System Assessment
- Technical Memorandum 4 – Stormwater System Assessment

Wastewater treatment is an essential service provided by the City and is critical for protection of regional water quality. The Columbia Regional Wastewater Treatment Plant (CRWWTP) treats residential, commercial and industrial wastewater generated within the Columbia metropolitan area and is one of the City's most significant infrastructure assets. The CRWWTP's ability to accommodate growth in the community and comply with current and future regulations are vital considerations for the City during the IMP development process. This evaluation summarizes the current CRWWTP capacity and performance to help inform planning decisions regarding plant upgrades that may be required to meet anticipated future growth and regulatory requirements.

[1] Stoner, N. and C. Giles. 2012. Integrated Municipal Stormwater and Wastewater Planning Approach Framework. June 5, 2012. Washington DC.

Section 2. CRWWTP and Effluent Discharge Description

The CRWWTP consists of a mechanical treatment plant (**Figure 1**) followed by a series of four treatment wetlands units for additional wastewater treatment (**Attachment A**). The treatment wetlands are a unique feature of the CRWWTP. Constructed treatment wetlands use natural physical, biological, and chemical processes to remove a wide array of wastewater pollutants, including organics, nutrients, ammonia, metals, and bacteria. Treated effluent from the CRWWTP is discharged into the Eagle Bluffs Conservation Area (Eagle Bluffs) to provide a valuable water source for wildlife habitat.

Since the CRWWTP was initially constructed in 1983, more than 100 small WWTPs have been eliminated in Columbia. The CRWWTP continues to be an important regional wastewater treatment provider in the area. Currently, there are 38 domestic and 8 industrial wastewater treatment plants in or near Columbia (see Technical Memorandum 1). Of the 38 domestic National Pollutant Discharge Elimination System (NPDES) permits, 11 are decommissioning and joining either the CRWWTP or Boone County Regional Sewer Districts systems.

Figure 1. Aerial View of the Columbia Regional Wastewater Treatment Plant.

2.1 Mechanical Treatment Plant

The mechanical plant is strategically located at the confluence of Hinkson and Perche Creeks to maximize the use of gravity flow through the wastewater collection system. Mechanical plant treatment processes include:

- flow equalization,
- screening,
- grit separation,
- primary clarification,
- activated sludge treatment with clarification,
- anaerobic digestion,
- primary sludge thickening,
- waste activated sludge thickening
- sludge dewatering, and
- biosolids land application.

Wastewater treated through the mechanical plant flows into the constructed wetlands for additional treatment before being discharged to Eagle Bluffs. Screenings and grit are landfilled. Biosolids generated by the mechanical plant are primarily land applied on nearby farmland as a soil amendment or sent to a landfill.

2.2 Constructed Treatment Wetlands

The constructed treatment wetlands provide additional treatment of mechanical plant effluent prior to discharge to Eagle Bluffs. The four constructed treatment wetlands units are positioned along Perche Creek to enable gravity flow of wastewater through the wetlands units. Wastewater flowing through the wetlands is treated through the biological, chemical and physical interactions of aquatic plants (primarily cattails), sunlight, and sediment micro-organisms. The treatment wetlands cover 130 acres, making this one of the largest constructed treatment wetlands used for municipal wastewater treatment in the country.

2.3 Discharge to Eagle Bluffs Conservation Area

Effluent from the CRWWTP is pumped more than two miles and is discharged into the Eagle Bluffs Conservation Area (Eagle Bluffs), a 4,400 acre wetland and wildlife area. CRWWTP effluent is the primary source of water for wetland habitat in the expansive Eagle Bluffs aquatic system (**Attachment B**). Eagle Bluffs is managed by the Missouri Department of Conservation (MDC). This cooperative arrangement between the City and MDC represents one of the Nation's most prominent projects reclaiming wastewater effluent for wildlife habitat creation.

Once CRWWTP effluent enters Eagle Bluffs, MDC directs the water to various channels and pools to achieve MDC's wildlife management objectives. Occasionally, water from Eagle Bluffs is discharged for short durations into an unnamed Missouri River slough, which drains into the Missouri River. During Missouri River flood conditions, MDC can also drain flood waters from Eagle Bluff's downstream pools into Perche Creek, which likewise discharges into the Missouri River.

2.5 Recent CRWWTP Upgrade

The Missouri Department of Natural Resources (MDNR) establishes effluent quality requirements through the CRWWTP's NPDES discharge permit. In 2009, MDNR established an average monthly limit of 6.0 milligrams per liter (mg/L) of ammonia expressed as nitrogen (ammonia) to meet water quality criteria in Eagle Bluffs and the Missouri River. The City upgraded the CRWWTP to meet this new effluent limit). The plant upgrade and expansion was completed in 2013, at a total cost of approximately $64 million.

The upgrade increased the capacity of the entire CRWWTP, including the constructed treatment wetlands, from a design average flow (DAF) of 20.6 million gallons per day (MGD) to 25.2 MGD. The upgrade included the addition of two new mechanical plant treatment trains (**Figure 2**). The original mechanical plant had a capacity of 12.6 MGD and consisted of two parallel treatment trains, each rated at 6.3 MGD. These two trains were not designed for biological ammonia removal (nitrification). Two new treatment trains, also rated for 6.3 MGD each, were added during the upgrade, effectively doubling the mechanical plant capacity. The new treatment trains are designed to fully nitrify year round. Additionally, the anoxic zones in the new treatment trains provide the opportunity to reclaim alkalinity and some level of denitrification.

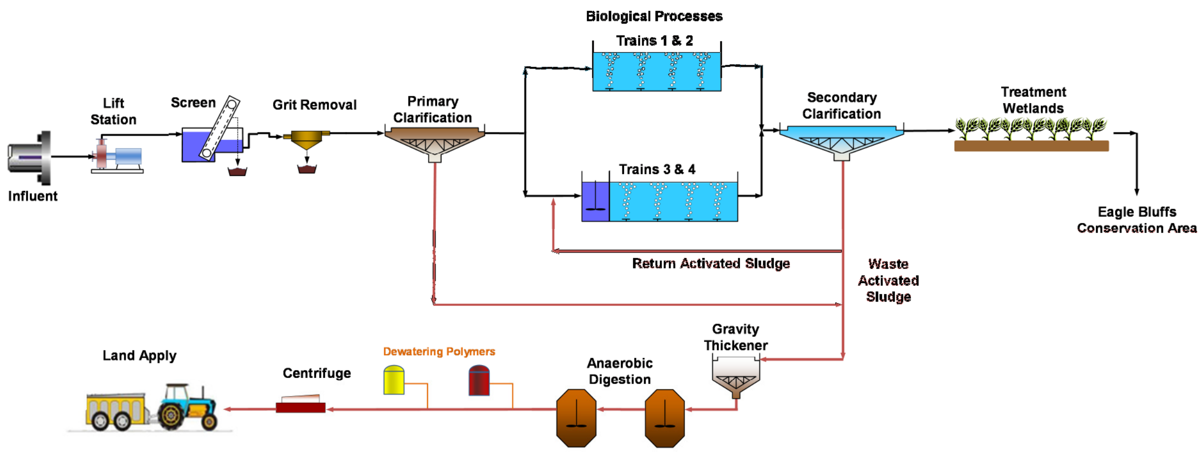

Figure 2. Process Flow Schematic of the Upgraded CRWWTP.

In addition to improvements and expansion of the secondary treatment trains, additional enhancements were made to the CRWWTP. These included upgrades to the headworks of the plant consisting of replacement of screening facilities and influent pumping units, wet well repairs, the construction of a grit removal facility and activated carbon odor control system. Upgrades to the solids handling portion of the treatment process included the construction of a biosolids dewatering facility, and construction of ferric chloride and polymer feed systems. Additional upgrades not related to the wastewater treatment system included a new potable water system, updates to site electrical systems, expansion of plant fire protection, the addition of natural gas to the site, road and perimeter security improvements, the construction of a new laboratory and administration building.

Section 3. CRWWTP Influent Loading

The first step in the performance evaluation was to compare average daily plant influent loading rates to design average loading rates for the recent plant upgrade. Average influent loading rates from 2007 through year-to-date (YTD) 2016 were selected to characterize actual influent loading. This date range includes five years of data before the upgrade and over three years of data following the upgrade.

Four influent parameters included in the evaluation were:

- Flow
- 5-day Biochemical Oxygen Demand (BOD_5)
- Total Suspended Solids (TSS)
- Ammonia

3.1 Influent Flow

CRWWTP annual daily average influent flow rates were well below the 25.2 MGD design average flow rate (**Figure 3**). The observed variation in the annual influent flow rates was likely due to variations in annual precipitation differences.

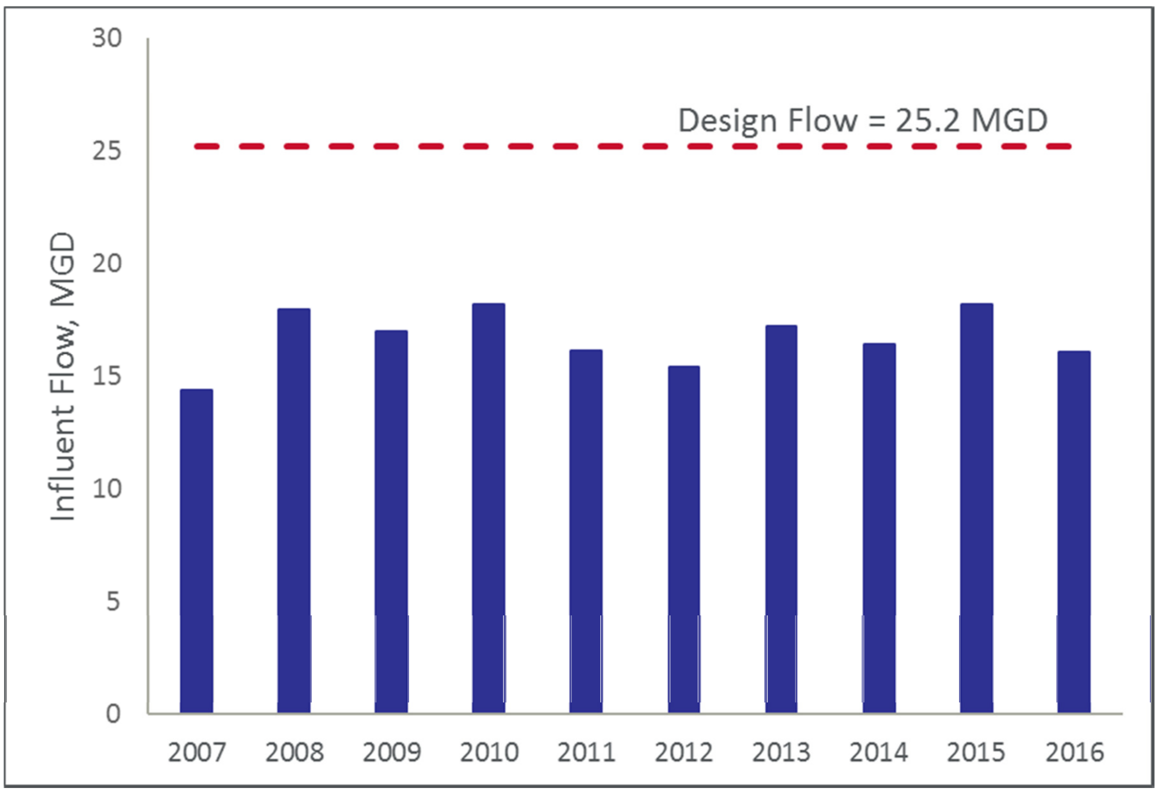

Figure 3. CRWWTP Annual Average Influent Flow 2007 through July 2016.

3.2 Influent Biochemical Oxygen Demand and Total Suspended Solids

Biochemical Oxygen Demand (BOD_5) is the measurement of the dissolved oxygen consumed by microorganisms in a water sample over a five-day period. BOD_5 is removed in the CRWWTP so that the effluent discharged from the plant will not create low dissolved oxygen conditions that may impact aquatic life downstream. TSS is a measurement of the quantity of suspended solid particles in a sample. TSS effluent limits are established to reduce the potential impacts of suspended solids on downstream aquatic life, habitat, and other biological and chemical characteristics.

CRWWTP BOD_5 and TSS loadings were evaluated based on mass loading, expressed as pounds per day (lbs/day). The influent sampling location for this data set includes the raw influent plus internal sidestream return loads. The annual average influent BOD_5 and TSS loadings from 2007 through July 2016 were approximately 40,400 lbs/day and 47,300 lbs/day, respectively. All annual average BOD5 and TSS loadings were below the design loading rates (**Figure 4, Figure 5**).

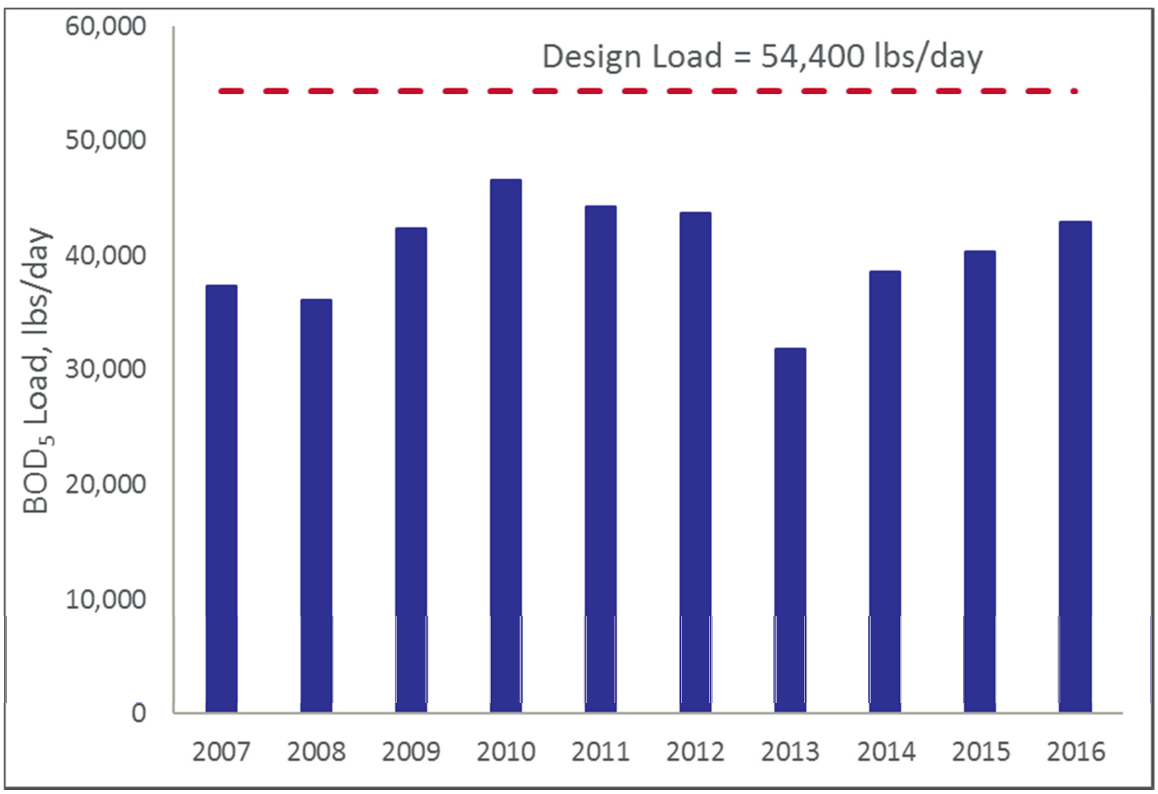

Figure 4. Actual Average Influent BOD_5 Load Compared to Design Influent BOD_5 Load.

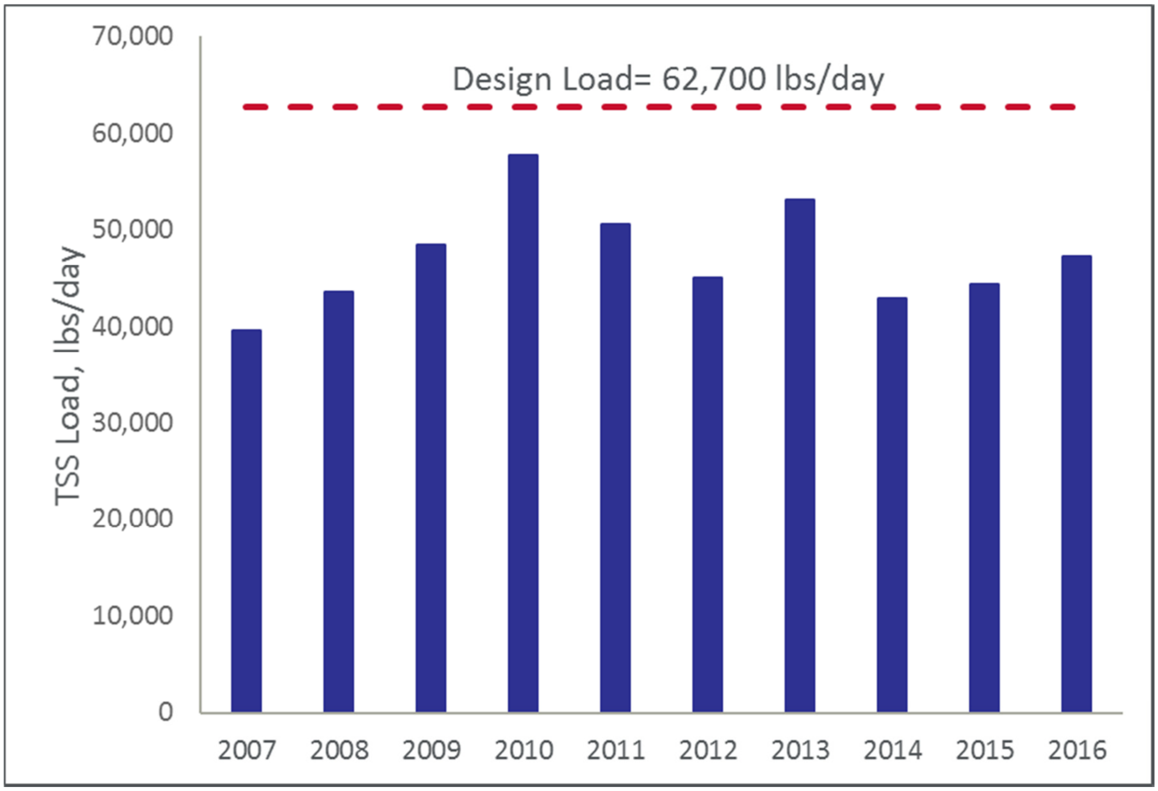

Figure 5. Actual Average Influent TSS load Compared to Design Influent TSS Load.

3.3 Influent Ammonia

Ammonia is present in domestic wastewater as a by-product of human digestion. In elevated concentrations, ammonia is toxic to aquatic life and can also contribute to dissolved oxygen depletion. As earlier described, the City upgraded the CRWWTP with the addition of two mechanical plant treatment trains that nitrify ammonia to meet the new ammonia permit limits required by MDNR and EPA.

3.3.1 Ammonia Design Effluent Limits and Treatment Trains

The CRWWTP upgrade was designed to meet an average monthly ammonia effluent limit of 6.0 mg/L ammonia at the design flow of 25.2 MGD by combining the effluent from the two existing trains that partially nitrify with effluent from the two new trains that fully nitrify. This combination should produce a typical effluent ammonia concentration below 1 mg/L (expressed as nitrogen). The original two treatment trains have enough volume and aeration capacity to support full nitrification at flows up to 2.2 MGD per basin. Therefore, the full nitrification capacity of the existing four trains is 17.0 MGD (6.3 MGD each from the two new trains and 2.2 MGD each from the two original trains. The current average flow is approximately 17 MGD, so the facility should be able to fully nitrify under current plant flow conditions.

3.3.2 Ammonia Loading and Trends

The average ammonia loading over the evaluation period was approximately 2,800 lbs/day; consistently below the influent design loading rate (with sidestream return flows) of 5,400 lbs/day. CRWWTP influent ammonia loadings have shown an upward trend (Figure 6Error!

Reference source not found.). The ammonia load has increased approximately 15 percent from 2012 to 2016. Approximately half of the increase can be attributed to sidestream contributions from the dewatering facilities constructed as part of the plant upgrade. The source of the remaining ammonia increase was not readily apparent. Ammonia data collected in the future will confirm if this upward trend continues and the whether the potential sources may be attributed to plant operational changes or influent loading from the collection system.

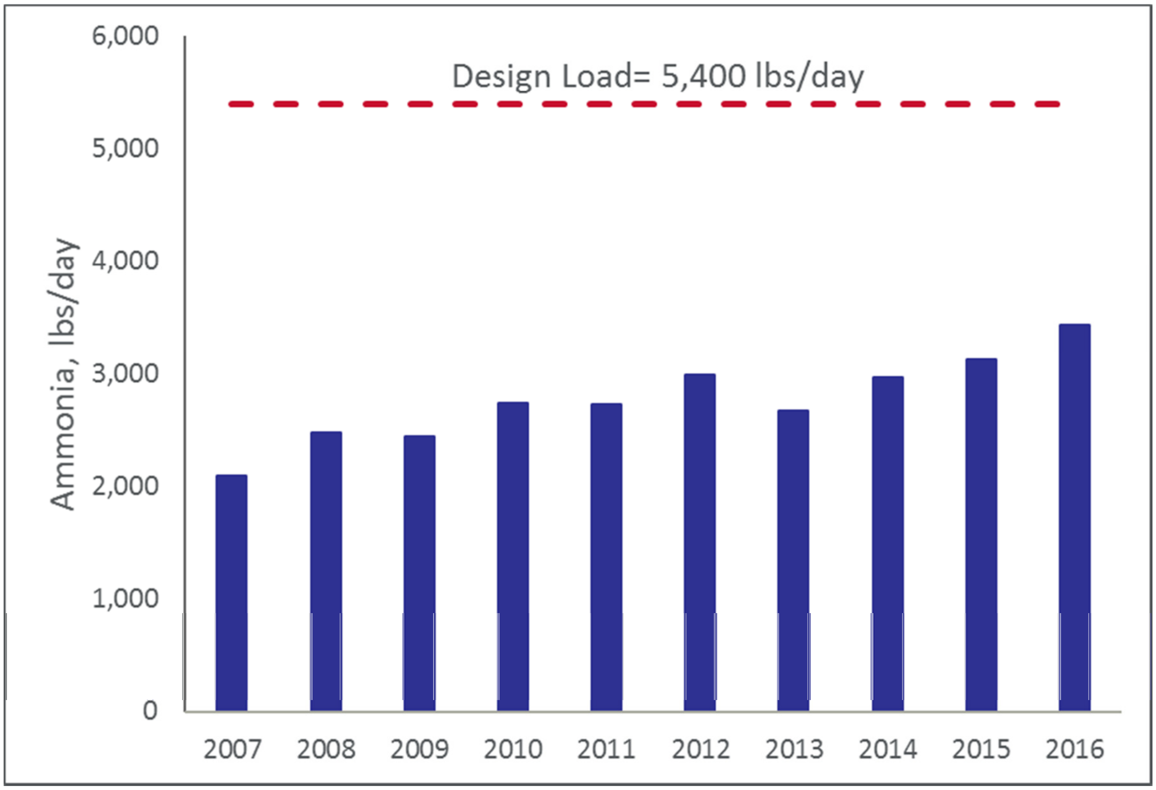

Figure 6. Actual Average Influent Ammonia Load.

Section 4. CRWWTP Treatment Performance

The performance of the CRWWTP was evaluated by comparing BOD_5, TSS and ammonia final effluent concentrations before and after the plant upgrade. The effluent concentrations were measured after the effluent had passed through the constructed treatment wetlands, at the wetlands pump station (WLPS). For each parameter, effluent concentrations are summarized in box and whisker plots[2] that compare the three years of concentration measurements prior to the plant upgrade (2007 through 2009) with effluent concentration measurements following the upgrade (2014 through YTD 2016). For each parameter, lower effluent concentrations indicate better treatment plant performance.

4.1 BOD_5 and TSS

The primary objective of the mechanical plant upgrade was to reduce effluent ammonia concentrations. Both effluent BOD_5 and TSS concentrations were satisfactory before the upgrade. However, these parameters were included in the post-upgrade evaluation to identify potential changes or trends. CRWWTP effluent BOD_5 concentrations decreased following the plant upgrade (**Figure 7**), with an average decrease of approximately 30 percent. CRWWTP effluent TSS concentrations (**Figure 8**), although slightly higher in 2016 (through July) measurements, remained consistent during the evaluation period.

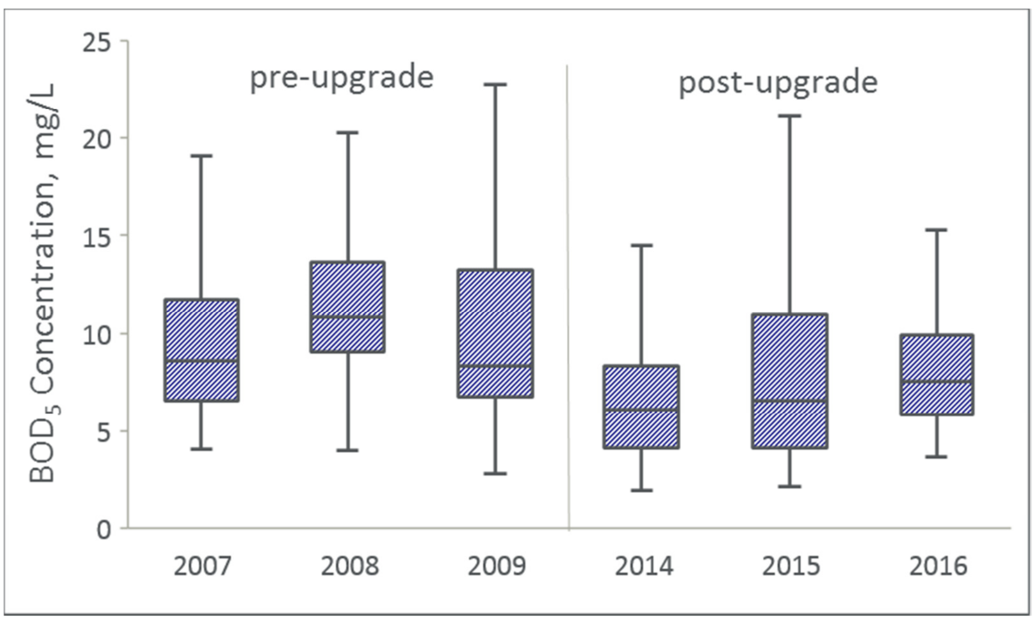

Figure 7. WLPS Effluent BOD_5 Concentration before and After the CRWWTP Upgrade.

[2] Boxes represent 25 to 75 percent of the results in a given year. The median result is displayed as a line in the box and the ends of the whiskers represent the maximum and minimum values, excluding statistical outliers.

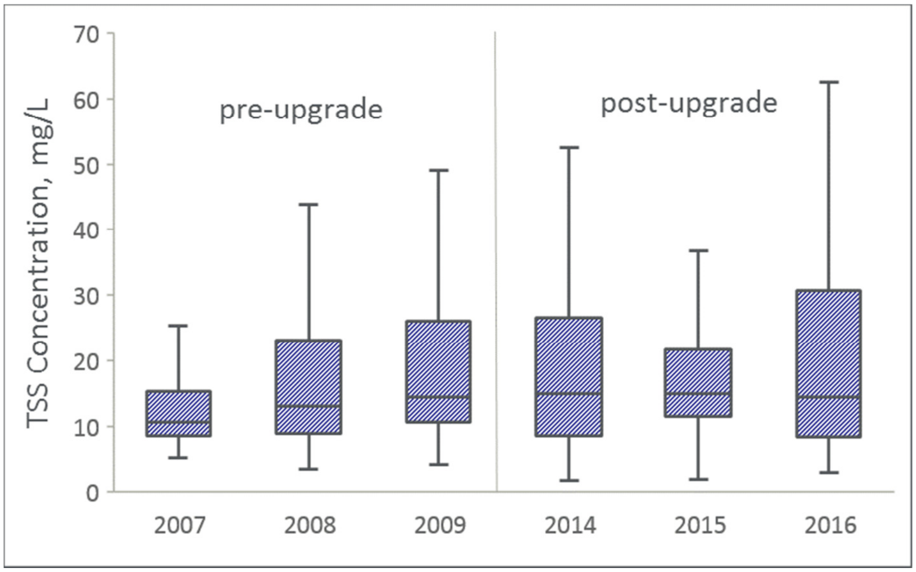

Figure 8. WLPS Effluent TSS Concentration before and After the CRWWTP Plant Upgrade.

4.2 Ammonia

As expected, effluent ammonia concentrations decreased appreciably following the plant upgrade (**Figure 9**). The median (50th percentile) pre-upgrade ammonia concentration was 14 mg/L and the median post-upgrade ammonia concentration was 1.7 mg/L, indicating an 88 percent reduction. With the exception of intermittent excursions during the upgrade startup period, CRWWTP effluent ammonia concentrations were consistently well below the draft 6.0 mg/L design monthly average, indicating that the primary objective of the plant upgrade had been achieved.

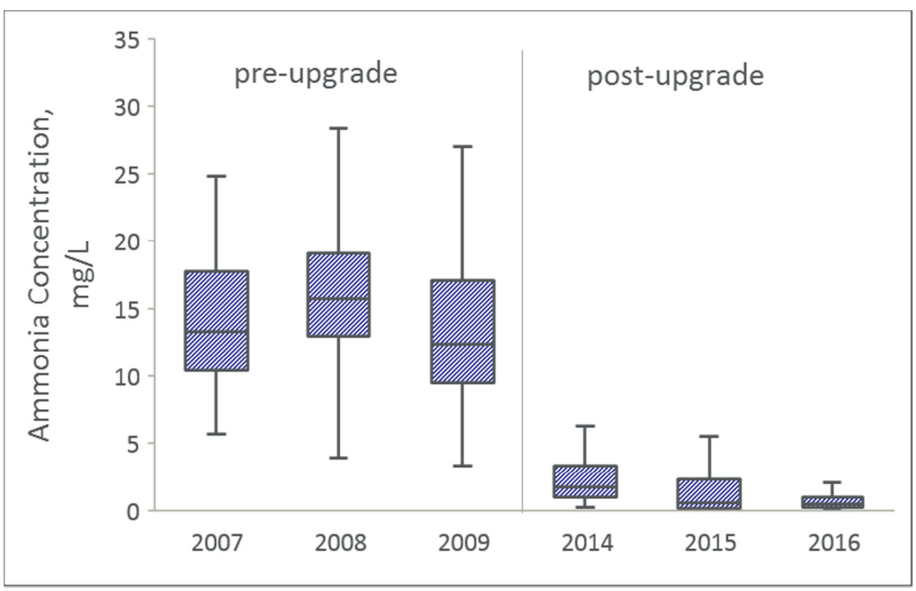

Figure 9. WLPS Effluent Ammonia Loading Before and After the CRWWTP Upgrade.

Section 5. Permit Limits Compliance

The CRWWTP's ability to comply with current NDPES discharge permit limits is an important consideration in the IMP process. To assess compliance, permit limit exceedances over a five-year period (2010 through 2014) were identified for all parameters with current numeric permit limits. This time period coincided with the compliance assessment included in the City's most recent NPDES permit application. With the exceptions of TSS and infrequent exceedances of metals, the CRWWTP consistently complied with effluent limits.

5.1 TSS Excursions due to Waterfowl

Large numbers of waterfowl overwinter on the constructed treatment wetlands and neighboring Eagle Bluffs wetlands. These birds agitate sediments in the wetlands, causing elevated TSS concentrations that occasionally exceed permitted TSS limits (**Figure 10, Figure 11**). During months with TSS excursions, MDNR requires the City to submit documentation of heavy waterfowl use. With this documentation submitted, the City if in compliance with permit limits and conditions. Based on recent MDNR correspondence, the next permit renewal will include more relaxed average weekly (AWL) and average monthly (AML) TSS limits during periods of heavy waterfowl.

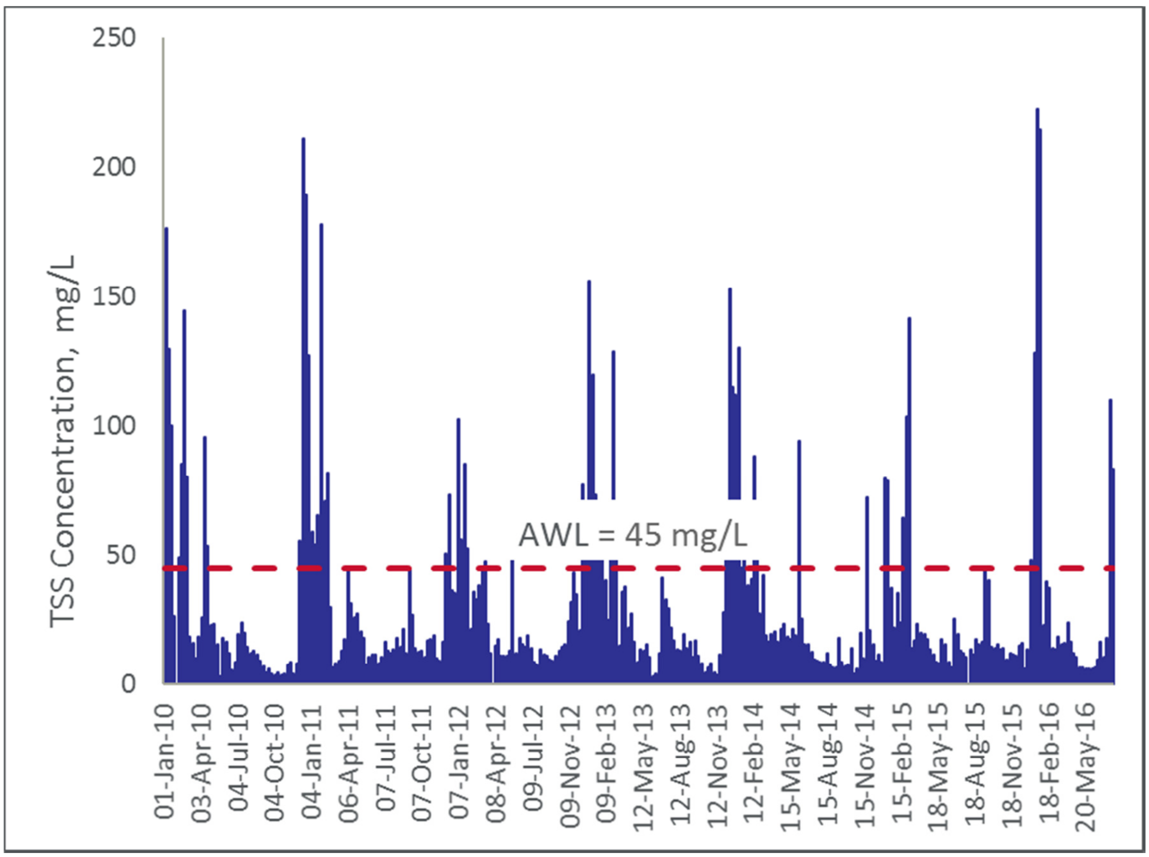

Figure 10. WLPS Effluent Weekly Average TSS Concentrations.

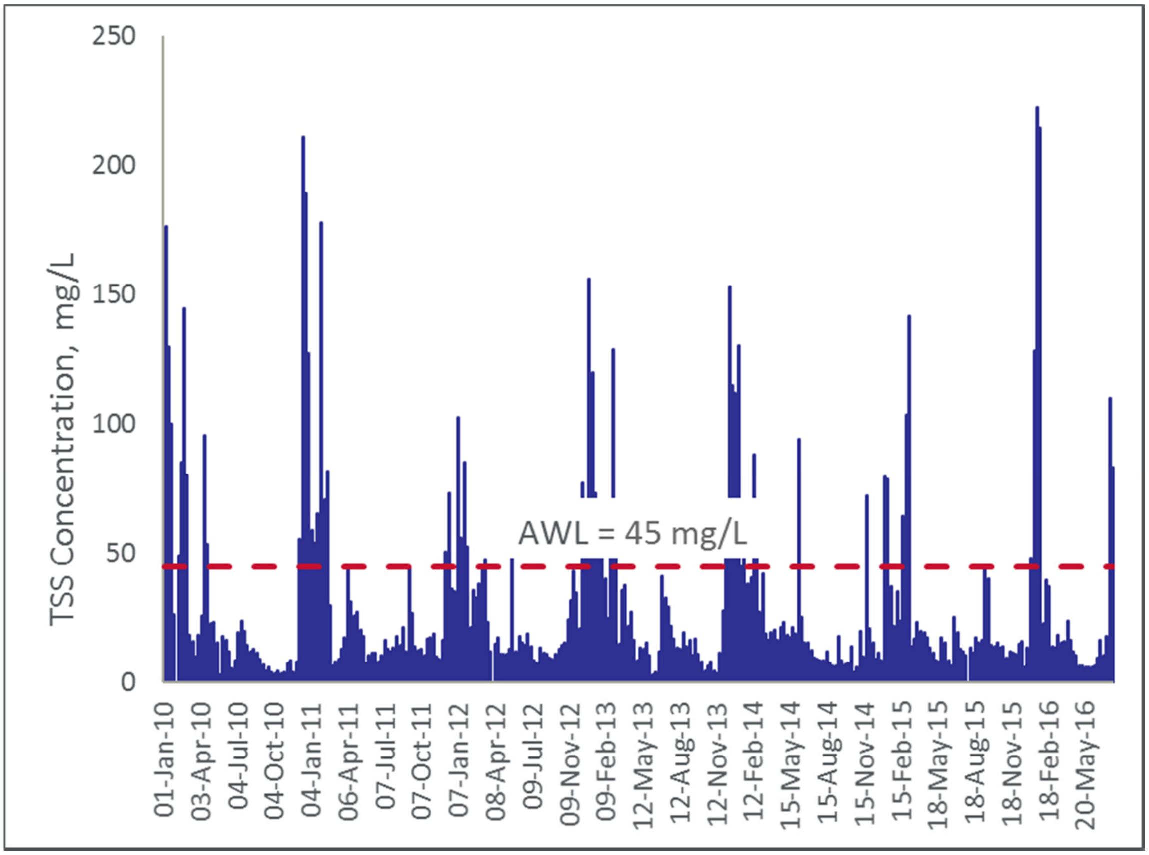

Figure 11. WLPS Effluent Monthly Average TSS Concentrations.

5.2 Compliance with Secondary Treatment BOD_5 and TSS Removal Requirement

Consistent with federal regulations dictating secondary treatment performance, the CRWWTP NPDES permit requires that the treatment plant remove 85% of the BOD_5 and TSS that enters the plant, as determined based on monthly average concentrations. The CRWWTP consistently meets this requirement aside from months of elevated TSS associated with heavy waterfowl activity on the constructed treatment wetlands.

5.3 Compliance with Whole Effluent Toxicity Testing

The CRWWTP NPDES permit also requires the City conduct an acute whole effluent toxicity (WET) test annually. The acute WET test measures the survival rate of test organisms placed in effluent samples for a 48-hour period. All WET tests conducted on CRWWTP effluent during the evaluation period passed, showing absence of acute toxicity.

5.4 Preliminary Bacteria Measurements

Although not required in the current CRWWTP permit, the City has proactively measured bacteria concentrations in both the mechanical plant and final effluents. The bacteria measurements show that, following the plant upgrade, the combination of the mechanical plant and the constructed treatment wetlands reduce bacteria to levels that, on average, are below the secondary contact recreation criterion, which may be applicable to EBCA in the future (**Figure 12**).

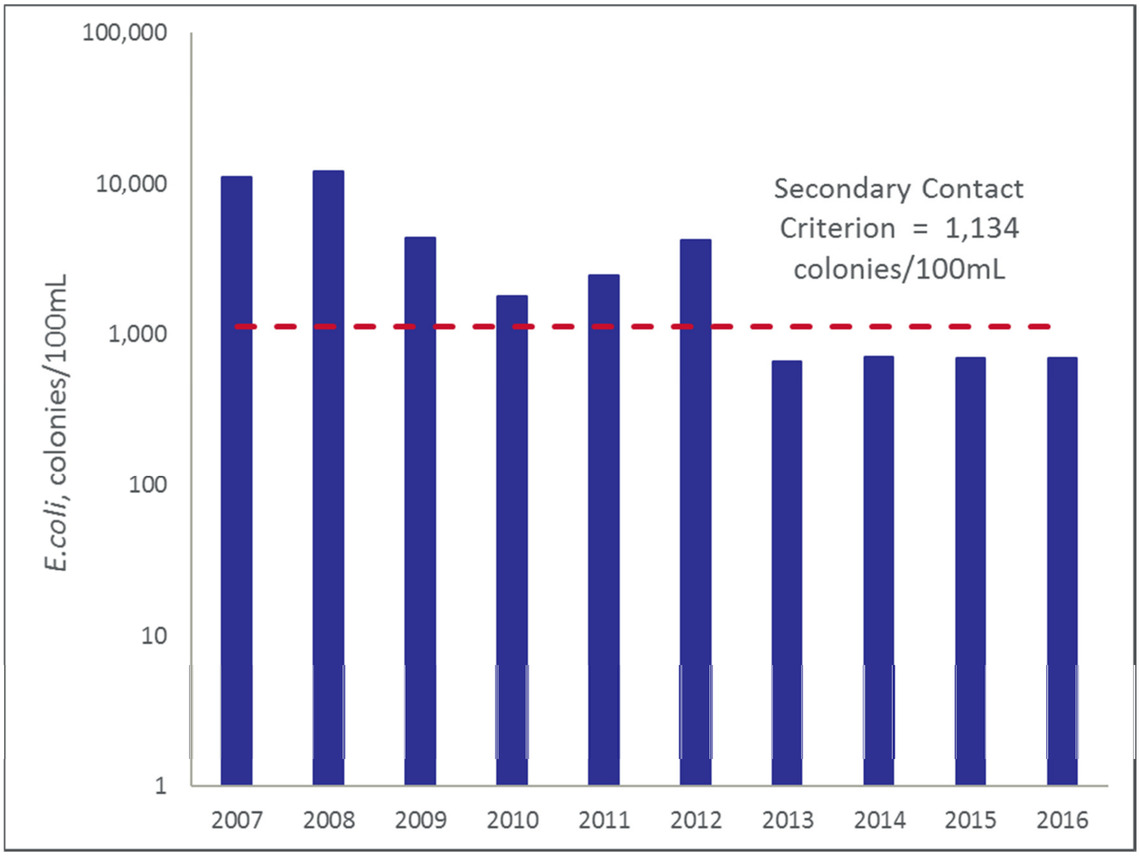

Figure 12. WLPS Effluent Annual Geometric Mean *E.coli* Concentrations.

Section 6. Summary

The CRWWTP performance assessment findings and summary points are as follows:

- Annual average influent flow, BOD_5 and TSS loadings have remained generally consistent since 2007.

- Annual average flow, BOD, TSS and ammonia loadings were consistently below the plant upgrade design criteria.

- Following the plant upgrade, the CRWWTP reduced the average annual ammonia influent concentrations by approximately 90 percent. Average effluent ammonia concentrations were consistently below the draft permit effluent ammonia limit. These findings confirm that the primary objective of the upgrade (ammonia removal) was achieved. Intermittent effluent ammonia concentration variability during the expanded plant startup period can be expected to be further reduced as process control measures are refined.

- Annual average influent ammonia loadings have shown a steady upward trend over the last several years. Much of this increase was expected due to the rerouting of internal sidestreams following the plant upgrade. The remaing portion of the increase was not yet identified. Ammonia loading trends should continue to be evaluated further to help identify ammonia loading sources.

- Average annual plant effluent BOD_5 concentrations decreased by approximately 30% following the plant upgrade.

- With the exceptions of waterfowl-related TSS excursions, the CRWWTP consistently complied with permit effluent limits.

- Average annual plant effluent *E. coli* concentrations were appreciably reduced following the plant upgrade. The annual average, post-upgrade *E. coli* concentrations were consistently below Missouri's secondary contact water quality criterion.

Technical Memorandum 3 Attachments

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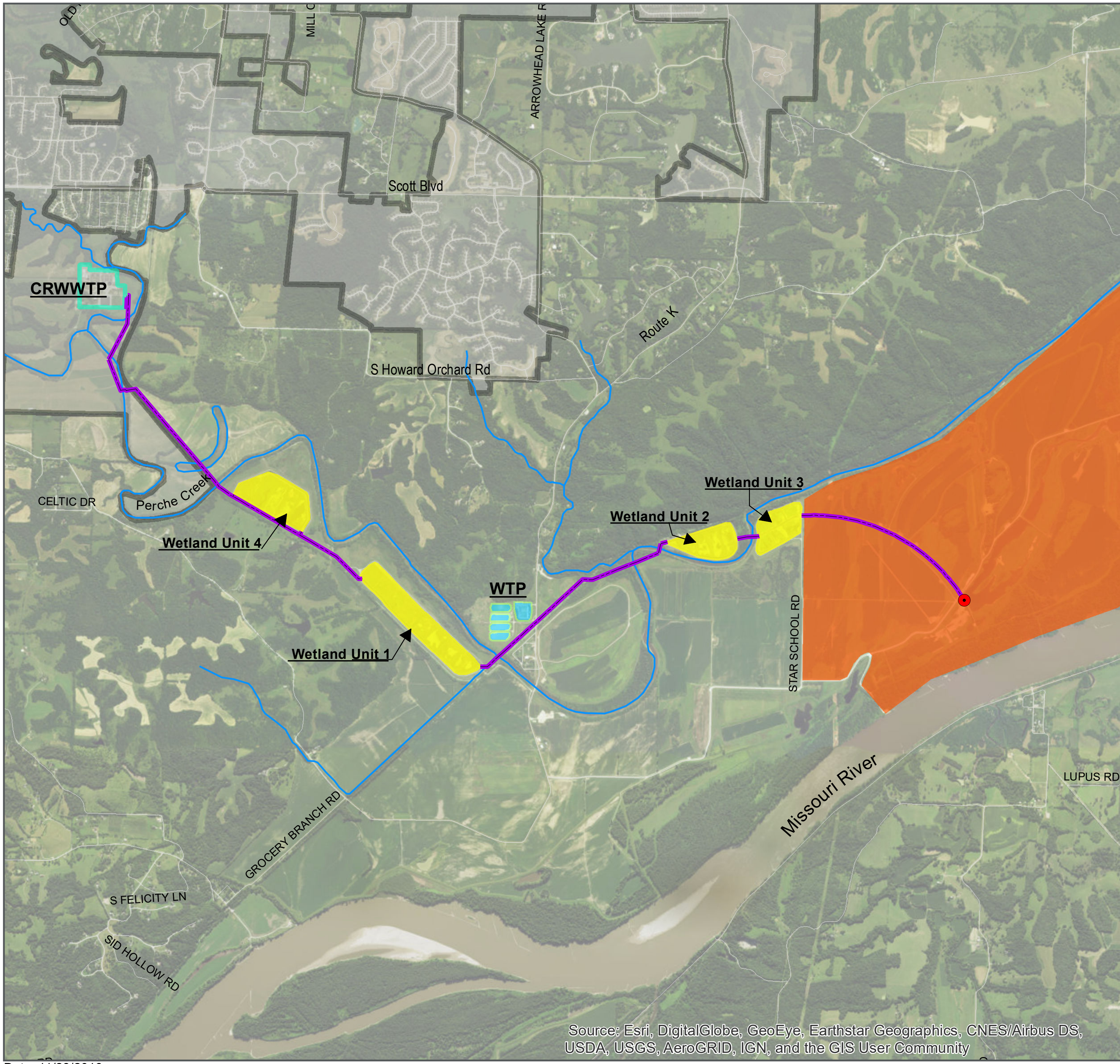

Our Columbia Waters
Integrated Management Plan
Wastewater & Stormwater

Legend

- Eagle Bluffs Junction Box
- Effluent Pipleine
- Columbia Regional Wastewater Treatment Plant
- McBaine Water Treatment Plant
- Treatment Wetlands
- Eagle Bluffs Conservation Area
- Columbia City Limits

**ATTACHMENT A
COLUMBIA REGIONAL WASTEWATER TREATMENT PLANT & EAGLE BLUFFS CONSERVATION AREA**

CITY OF COLUMBIA MISSOURI

WASTEWATER & STORMWATER INTEGRATED MANAGEMENT PLAN

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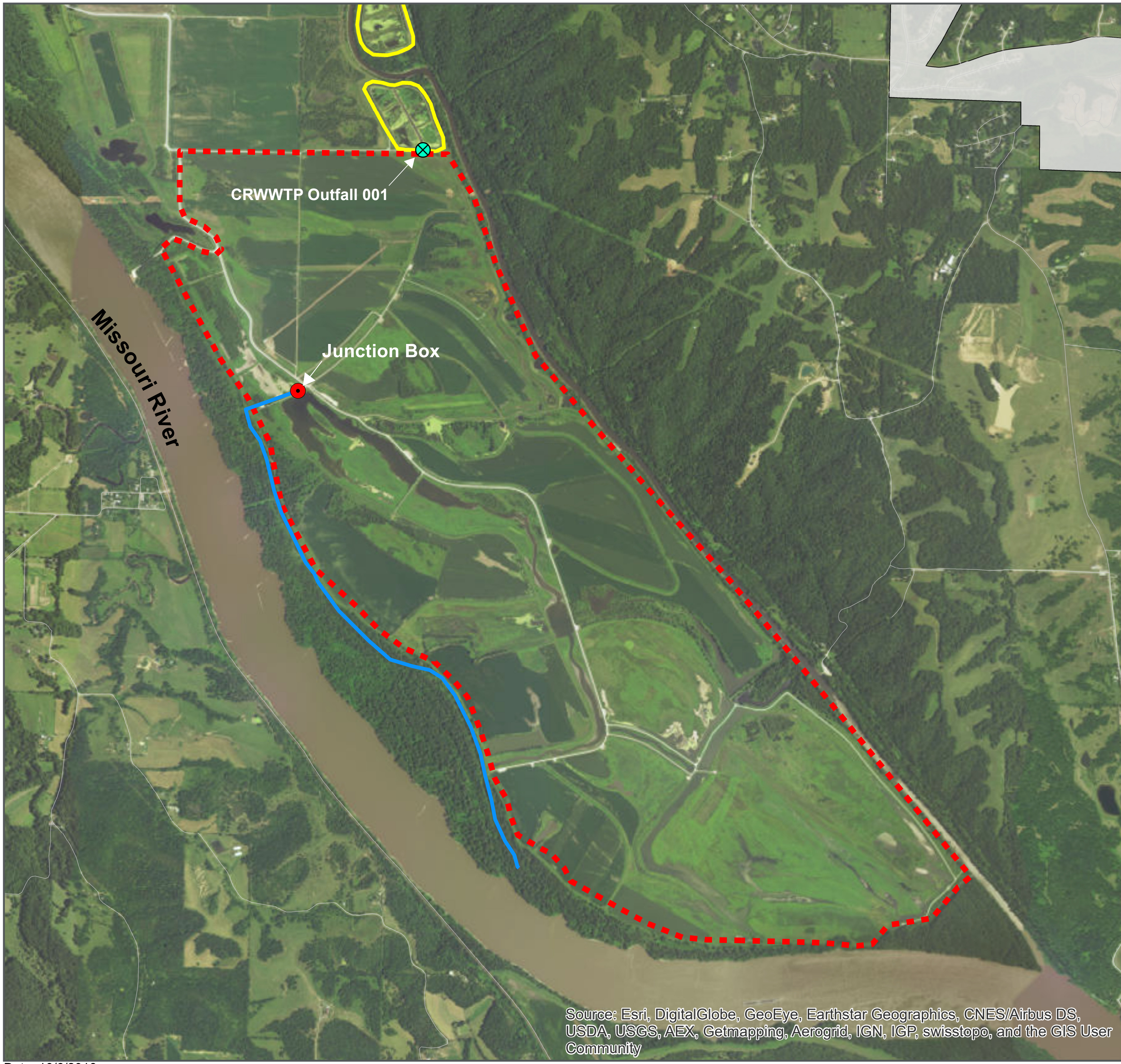

Our Columbia Waters
Integrated Management Plan
Wastewater & Stormwater

Legend

- CRWWTP Outfall 001
- Junction Box
- River Slough
- Eagle Bluffs Conservation Area
- Treatment Wetlands
- Roads
- Columbia City Limits

ATTACHMENT B
EAGLE BLUFFS CONSERVATION AREA WETLANDS

CITY OF COLUMBIA MISSOURI

WASTEWATER & STORMWATER INTEGRATED MANAGEMENT PLAN

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Columbia Wastewater and Stormwater IMP

Attachment H

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Our Columbia Waters
Integrated Management Plan
Wastewater & Stormwater

Technical Memorandum 4 *Stormwater System Evaluation*

Columbia Wastewater and Stormwater Integrated Management Plan

Columbia, Missouri
February 16, 2017

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Section 1. Introduction and Objectives

The City of Columbia, Missouri (City) is working to develop an Integrated Management Plan (IMP) for the City's wastewater and stormwater utilities. The goal of the IMP is to develop an adaptable and affordable long-term plan that addresses the City's wastewater and stormwater management needs and meets Clean Water Act requirements. The IMP will be developed based on guidance presented in US Environmental Protection Agency's (EPA) *Integrated Municipal Stormwater and Wastewater Planning Approach Framework* (Stoner 2012).

A critical step in the IMP includes evaluating the City's environmental resources and infrastructure assets to better define the existing condition, performance, and needs of its systems. This evaluation is important because it forms the basis for identifying priorities and developing alternatives in subsequent phases of the IMP. To develop a comprehensive understanding of existing conditions, the City and their project team compiled and evaluated existing surface water, wastewater, and stormwater data. These data, as well as current operation and maintenance practices and procedures, were then reviewed and discussed in a series of workshops. Results from these efforts are documented in the following technical memoranda:

- Technical Memorandum 1 – Surface Water Quality and Biological Conditions
- Technical Memorandum 2 – Wastewater Collection System Assessment
- Technical Memorandum 3 – Wastewater Treatment System Assessment
- Technical Memorandum 4 – Stormwater System Assessment

This purpose of this memorandum is to summarize findings from the stormwater system assessment. Effective management and efficient implementation of the stormwater program is necessary for meeting important environmental and public safety goals such as improving water quality, minimizing flooding impacts, and reducing property damage. To develop a better understanding of the City's existing stormwater assets, representatives from HDR Engineering, Inc. (HDR), met with City staff on August 10 to discuss these goals and identify the City's priorities and level of service (LOS) expectations. HDR, Geosyntec Consultants, Inc. (Geosyntec), and other members of the project team also compiled relevant data and worked with the City to inventory the existing system, review its performance, and evaluate capacity. Results from the evaluation are documented in the sections that follow.

Section 2. Stormwater System Inventory

The City has collected an impressive amount of data on their stormwater system, the majority of which are entered into their Geographic Information System (GIS) database. There are nearly 14,000 City-owned storm structures in the database including manholes and inlets (**Table 1**). Curb inlets and end structures make up the majority of the system structures.

Table 1. Stormwater Structure Inventory by Installation Date.

Installation Date	Structure Type				
	Area Inlet	Curb Inlet	End Structure	Junction	Other*
Pre-1960	105	241	153	73	1
1960-1970	110	576	405	92	9
1970-1980	63	349	372	63	4
1980-1990	162	1,006	828	197	3
1990-2000	229	1,445	1,030	230	7
2000-2010	484	2,135	1,334	514	7
2010-Present	246	752	367	287	9
Total	**1,399**	**6,505**	**4,488**	**1,457**	**40**

*31 Structures are of unknown type.

Of the nearly 14,000 structures, approximately 7% have a condition rating associated with them (**Table 2**). Approximately 96% of the structures with condition ratings are considered to be in either fair or good condition.

Table 2. Stormwater Structure Condition Assessment Summary.

Type	Number of Structures with Condition Scores					
	No Score	Critical	Failing	Poor	Fair	Good
Area Inlet	1,337	0	0	1	13	48
Curb Inlet	6,043	2	2	6	65	387
End Structure	4,173	1	7	10	77	221
Junction	1,411	0	1	0	5	41
Other*	39	0	0	0	1	0
Total	13,004	3	10	17	161	707
% of Total Rated	**--**	**0.3%**	**1.1%**	**1.9%**	**17.9%**	**78.7%**

Notes:
Only 7% of all structures in the database have a condition assessment associated with them.
*31 structures are of unknown type.

The database also lists pipe material types, pipe size and age of the system installed. The City populated the system by reviewing past construction plans and entering the information. A visual condition assessment of curb inlets has been performed sporadically, but less than 1% of the piping system has been inspected. The GIS database includes approximately 930,000 feet of stormwater pipes that are under municipal control (**Table 3**). This estimate excludes private stormwater systems and systems within the Missouri Department of Transportation (MoDOT) right of way. Approximately 89% of the system has the pipe type identified and corrugated metal pipe (CMP) is the most common (**Table 3, Attachment A**).

Table 3. Stormwater Pipe Inventory Itemized by Material Types and Sizes.

Pipe Material	Pipe Length (ft.)					
	< 18 inch diameter	18-36 inch diameter	36-54 inch diameter	> 54 inch diameter	Unknown	Total
Corrugated Metal (CMP)	78,306	202,950	53,208	10,313	9,534	**354,310**
High Density Polyethylene (HDPE)	56,706	67,020	13,283	1,234	123	**138,367**
Reinforced Concrete (RCP)	65,966	134,722	49,143	12,090	4,816	**266,737**
Polyvinyl Chloride (PVC)	2,095	-	-	-	-	**2,095**
Vitrified Clay (VCP)	9,738	8,311	770	-	-	**18,819**
Bitunimous Coated Corrugated Metal (BCCMP)	1,492	3,186	98	-	268	**5,044**
Corrugated Polyethylene (CPEP)	548	1,792	-	-	-	**2,340**
Corrugated Polypropylene (CPP)	268	82	-	-	-	**350**
Other	540	945	-	415	1,946	**3,846**
Reinforced Concrete Box (RCB)	-	-	-	-	229	**33,678**
Unspecified/ Unknown	4,255	5,461	1,831	-	91,717	**103,264**
Total	**219,914**	**424,470**	**118,334**	**24,051**	**108,403**	**928,850**

The GIS database also contained the age of the stormwater pipes for approximately 70% of the pipes. The City frequently updates information when new segments of storm pipe are installed on retrofit and roadway projects, but has not yet estimated the age of for the remaining 30% of missing records. To develop a more holistic understanding of the system and potential future needs, age was estimated by assuming that storm pipe age would approximately equal the age of the nearest adjacent sanitary sewer pipes. Aging of the sanitary lines was based on subdivision age, pipe material type, and other methods as described in Technical Memorandum 2. Results of the age assessment show that nearly 50% (431,020 feet) of the stormwater pipes in the City have been installed since the year 2000 (**Table 4, Attachment B**).

Table 4. Stormwater Pipe Inventory by Age.

Pipe Material	Pipe Length (ft.) by Installation Date						
	Pre-1960	**1960-1970**	**1970-1980**	**1980-1990**	**1990-2000**	**2000-2010**	**2010-Present**
CMP	9,251	35,948	28,866	54,079	99,927	105,356	20,884
HDPE	1,739	3,016	40	629	8,623	70,670	53,650
RCP	9,288	12,258	7,883	50,856	64,738	86,708	35,006
RCB	3,096	3,306	2,760	6,358	5,268	6,889	6,002
PVC	-	14	-	235	314	666	866
VCP	5,405	2,614	77	1,328	853	4,555	3,987
BCCMP	119	4,499	-	42	287	98	-
CPEP	-	130	-	-	986	1,224	-
CPP	130	-	-	28	-	193	-
Other	1,230	152	444	230	466	999	323
Unknown	14,102	9,903	9,904	14,802	21,607	22,074	10,872
Total	**44,359**	**71,841**	**49,974**	**128,588**	**203,068**	**299,432**	**131,588**

Notes:
70% of pipe age based on existing database construction year values.
30% inferred based on assessed sanitary pipe age based on neighborhood age and other analysis.

Similar to the stormwater structures, less than 1% (approximately 7,000 feet) of the stormwater pipe length has been assigned a condition assessment rating in the database (**Table 5**). Of the structures with a rating, 76% (approximately 5,300 feet) are rated as good and 16% (approximately 1,700 feet) are rated as either critical, failing or in poor condition.

Table 5. Stormwater Pipe Condition Assessment Summary.

Pipe Material	Pipe Length (feet) with Condition Scores					
	No Score	**Critical**	**Failing**	**Poor**	**Fair**	**Good**
CMP	351,188	221	172	225	397	2,107
HDPE	136,455	-	-	-	-	1,912
RCP	265,872	-	51	-	-	815
RCB	33,606	-	-	52	-	20
PVC	2,095	-	-	-	-	-
VCP	18,687	101	-	-	-	31
BCCMP	4,990	-	-	-	-	54
CPEP	2,340	-	-	-	-	-
CPP	350	-	-	-	-	-
Other	3,760	-	85	-	-	-
Unknown	102,488	-	-	234	178	364
Total	**921,832**	**322**	**309**	**511**	**575**	**5,302**

Since a large portion of the system has not been inspected, an assumed design life was estimated. The life span of the material types will vary widely based on induced stresses, installation methods, proximity to groundwater and soil corrosiveness. For example, in recent years the City has experienced several structural failures of CMP due to corrosion. In general, the CMP has an average lifespan of 30-years before it rusts and leads to structural deficiencies that cause sink holes, flooding, or pavement failures (**Figure 1**). According to the data reviewed as part of this evaluation, approximately 128,000 feet of CMP is more than 30 years old and would be expected to have sections of structurally deficient pipe. In the next 10 years, the length of CMP beyond the useful life will approach 225,000 feet (**Table 4**).

Figure 1. Example of CMP Corrosion and Failure. CMP typically rusts along the bottom of the pipe until the corrosion compromises the structural integrity of the pipe. As a consequence of the corrosion, soil may wash into the pipe causing sink holes to develop or the pipe may collapse causing upstream flooding or pavement failure.

Section 3. Stormwater System Performance

As part of the system performance evaluation, the project team evaluated frequency, location, and severity of reported flooding issues; system capacity; and progress towards meeting water quality goals as defined in the City's municipal separate storm sewer system (MS4) permit. Results from these evaluations are outlined in the following sections.

3.1 Flooding Evaluation

The City has recorded storm drainage and flooding issues in a database since the early 1970's. The database records were developed from flooding reports and a community survey. The database includes 2,670 total reports classified as street flooding, house flooding, yard erosion and yard flooding. Some of the database entries were inconsistent, had data formatting issues, incomplete records, or missing addresses that could not be geocoded. The following sections discuss the reported flooding locations by type of flooding reported for the database records that were available to analyze using GIS (2,332 records).

3.1.1 Riverine Flooding

Flooding reports that fell within the 500-year FEMA floodplain were considered to be riverine flooding or at least significantly influenced by backwater elevations in the stream. Within the study area, there are 228 riverine flooding records (**Table 6, Attachment C**) and several locations with a high concentration of flooding reports (**Figure 2**). The City does not yet have the FEMA Risk-Map products so information on the depth, velocity and frequency of flooding can not be directly evaluated. Flooding reports from properties within the regulatory floodway will likely be more frequent and severe than flooding reports outside the floodplain. This assumption should be re-evaluated as more data becomes available.

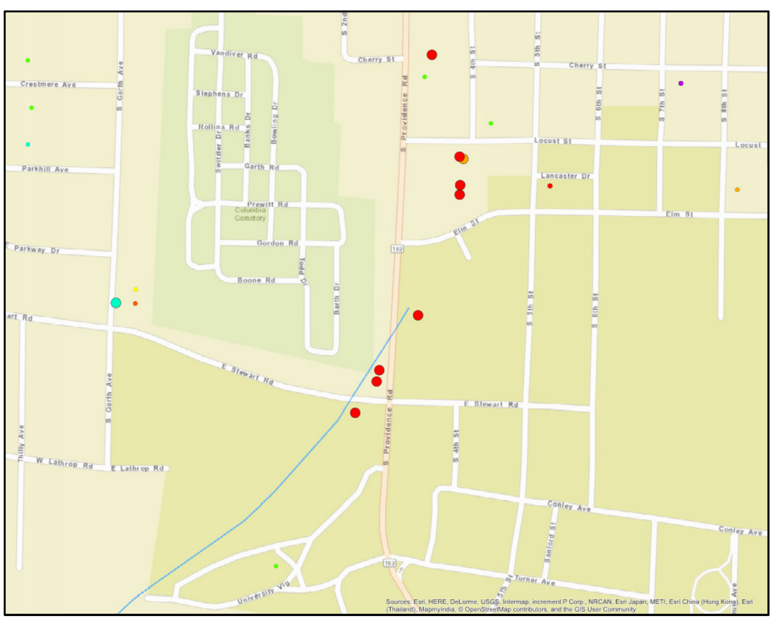

Figure 2. Example of Concentrated Flooding Reports.

Table 6. Riverine Flooding Reports.

Flooding Location	Number of Reports
Floodway	46
Floodplain	50
500 Yr. Annual Chance	132
Total	**228**

3.1.2 Street, House and Yard Flooding

Flooding reports were also analyzed outside of the floodplain. The flooding reports were recorded through questionaries initiated by the City and by individual citizens contacting the City (**Table 7**). Areas such as South West Blvd. and Ridge Road, Morningside Drive, and Gillespie Bridge Road have severe flooding reports and are likely more problematic than private property considerations alone. Reports which included house, yard and street flooding are coded as red on **Attachment D**.

Table 7. Reported Street, House and Yard Flooding Outside of the Regulatory Floodplain.

Flooding Location	Number of Reports
House, Yard, & Street	30
House & Street	18
Street Only	198
Yard & Street	68
House & Yard	131
House Only	92
Yard Only	638
Total	**1,175**

3.1.3 Depression Areas and Flooding Reports

Street and structure flooding is usually most severe in depression areas. Once the surface flows reach the roadway sumps, the depth and duration of exposure to the traveling public is increased. Likewise, houses and other structures adjacent to the depression areas may see additional basement flooding and flows in the side yards as the water depth increases. In order to help identify the most severe flooding areas from the large number of flooding reports, a depression map was superimposed on the flooding reports map. The MSDIS-published Boone County bare earth DEM, previously derived from LiDAR collected in 2009, was filled and then subtracted from the original DEM to produce depression areas. Flooding reports within 50 feet of these depression areas were then calculated. As expected, many of the persistent yard and street flooding reports occur near low depression areas (**Attachment E**).

3.1.4 Other Reports

Other flooding reports in the City are related to open channel flooding and yard erosion issues (**Table 8, Attachment F**). The City does not own or maintain natural channels (streams and creeks). The stormwater network contains eight engineered open channels that are actively maintained.

Table 8. Other Reports within the Flooding Database.

Description	Number of Reports
Open Channel Flooding	946
Reported Yard Erosion	769
Total	**1,715**

3.2 Conveyance System Capacity

Many of the new stormwater systems in residential and commercial subdivisions are installed by private land developers. Private developers are required to design and build the stormwater conveyance system to meet municipal requirements (ordinance 12A-95) and once built, the system is owned and operated by the City. The City's stormwater design standards are presented in the Stormwater Management & Water Quality Manual (Columbia 2009), which was approved by the public works director in February 2009 (Chapter12-A of the City Code of Ordinances) and recently updated in January 2015. The current design standards require adequate conveyance features and the routing of runoff to detention ponds prior to flow being released to downstream properties (**Table 9**). The detention ponds are intended to slow the runoff to match the rates experienced prior to development in order to prevent increasing downstream flooding.

Table 9. Summary of Key Stormwater Conveyance System Features Level of Service.

Stormwater Drainage Element	Street Classification		
	Local	Collector	Arterial
Street Spread Width	One 10 ft. lane open during 10 yr.	One 12 ft. lane open during 25 yr.	One Lane in each direction open during 25 yr.
Storm Pipes	10 yr.	25 yr.	100 yr.
Storm Pipes at Street Crossings	10 yr.	25 yr.	100 yr.
100-yr. Maximum Street Ponding Depth	14 in. at gutter 7 in. at crown	14 in. at gutter 7 in. at crown	14 in. at gutter 7 in. at crown
Open Channel	100 yr. plus 1 ft. of freeboard 10 yr. stability requirements		
Detention	1-, 2-, 10-, 100-yr. flows must not exceed greenfield or existing. 1 yr. used for stream protection flows.		
Water Quality Storm	1.3 inches in 24 hours. Reduction allowance for disconnected impervious areas.		
Rainfall Depth Duration Sources	TP-40, NRCS Type II, Bulletin 71 (Huff)		

Notes:
For complete design criteria see the Stormwater Management & Water Quality Manual (Columbia 2009).

The current design standards also include designing detention ponds for a "stream protection flow". Stream protection flows are intended to prevent increased erosion of the stream channel. These protections are needed because detention ponds are not able to reduce the overall volume of runoff, just the rate that leaves a property. Since the area upstream of a detention pond is usually covered with impervious areas like parking lots or buildings, less rainfall will soak into the ground and ultimately result in an increased volume of runoff. Increases in flow volume can lead to an increase in stream erosion. The City's current design standards do not require developers to mitigate for the increase in volume, just the peak rate of runoff.

The current design standards also use the Natural Resources Conservation Service (NRCS) Type II storm temporal distribution. This storm distribution is important when designing detention cells. The Type II storm distribution has a very intense rainfall pattern within the middle of the storm. When used, the NRCS Type II distribution generally predicts very high runoff rates for existing undeveloped conditions and for the future flows. Based on this method, a large detention cell outlet pipe is needed to convey the flows to downstream areas. This method may result in the detention ponds not holding back runoff from very intense storms and downstream flooding could result.

In contrast to the NRCS Type II distribution, the Bulletin 71 (Huff) temporal distribution will predict more moderate rates of existing runoff (Huff and Angel 1992). As a result, smaller pipe sizes are needed to convey flows to downstream areas. Detention pond outlets sized using this Bulletin 71 (Huff) method will generally hold runoff more frequently and tend to not pass large flows to downstream areas. Allowing both methods within the design manual may allow for contradictions in design and uncertainty in performance. Therefore to maintain consistency, only one temporal distribution should be used.

Recently, NRCS released a draft version of the National Engineering Handbook, *Chapter 4: Storm Rainfall Depth and Distribution* (2015). In this draft document, NRCS recommends not using a Type II distribution but rather using the updated rainfall depths and temporal distribution from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 (Perica et al. 2013). The NOAA Atlas 14 temporal distribution generally results in a less intense storm than the NRCS Type II but more intense than a Bulletin 71 (Huff) distribution for Columbia. The City may want to consider eliminating the NRCS Type II distribution from the list of approved storm temporal distributions since NRCS is no longer recommending its use.

3.3 Stormwater Quality Performance

The City, Boone County (County), and University of Missouri (MU) are permitted together as co-permittees under a Phase II MS4 permit (Permit No. MO-0136557) issued by the Missouri Department of Natural Resources (MDNR). The three entities are collectively responsible for compliance with their MS4 permit, which was recently reissued on June 1, 2016 (MDNR 2016). Federal (40 CFR 122.34) and state (10 CSR 20-6.200(5)(A)1-6)) regulations stipulate that MS4 permits include provisions for developing, implementing, and enforcing a stormwater management program and plan (SWMP) to reduce pollutant discharges to the maximum extent practicable (MEP).

The City's ability to fulfill its commitments to the other co-permittees and maintain compliance with the requirements of the MS4 permit is an important consideration for the IMP. The following summarizes an assessment of the co-permittees compliance with the MS4 permit requirements. The assessment was conducted through a review of the MS4 permit; the SWMP; the Collaborative Adaptive Management (CAM) Implementation Schedule and Agreement for

Hinkson Creek TMDL, dated March 2012; and MS4 Phase II Stormwater Annual Reports for 2011 through 2015. Additional information about the City's Stormwater Program was also obtained from the City's website.

3.3.1 Stormwater Quality Evaluation Objectives

To fulfill their MS4 permit requirements, the co-permittees have developed a Joint SWMP, which was also recently updated, in December 2015 (Boone County/Columbia/MU 2015). This SWMP states that the co-permittees "…have developed and implemented this program in order to protect water quality and effectively reduce stormwater pollutant runoff within their respective jurisdictions to the maximum extent practicable (MEP)."

The SWMP reflects federal (40 CFR 122.34) and state (10 CSR 20-6.200(5)(A)1-6)) regulations which require six (6) minimum control measures (MCMs) to meet the MEP standard. The six MCMs are:

1. **Public Education and Outreach –** Permittees are required to conduct outreach activities to communicate the impacts of stormwater and provide steps that the public can take to reduce pollutants in stormwater runoff.
2. **Public Involvement and Participation –** Permittees are required to provide opportunities for citizens to participate in program development and implementation.
3. **Illicit Discharge Detection and Elimination (IDDE) –** Permittees are required to develop and implement a plan to detect and eliminate illicit discharges to the storm sewer system.
4. **Construction Stormwater Runoff Control –** Permittees are required to develop, implement and enforce an erosion and sediment control program for construction.
5. **Post-Construction Stormwater Management in New Development and Redevelopment –** Permittees are required to develop, implement and enforce a program to address discharges of post-construction stormwater runoff from new development and redevelopment areas.
6. **Pollution Prevention and Good Housekeeping for Municipal Operations –** Permittees are required to develop and implement a program with the goal of preventing or reducing pollutant runoff from municipal operations.

The co-permittees are responsible for developing, implementing, and maintaining best management practices (BMPs), as well as measurable goals, for each of the six MCMs. The MS4 permit requires compliance with plans for any Total Maximum Daily Loads (TMDLs) in effect within the jurisdictions. The MS4 permit also requires the co-permittees to revise their SWMP within one year of receiving their operating permit (by June 1, 2017), if necessary, and to prepare and submit progress reports to MDNR every odd year during the life of the permit.

EPA (2001) defines measurable goals as "…BMP design objectives or goals that quantify the progress of program implementation and the performance of…BMPs." EPA further "…strongly recommends that measurable goals include, where appropriate, the following three components:

- The activity, or BMP, to be completed;
- A schedule or date of completion; and
- A quantifiable target to measure progress toward achieving the activity or BMP."

According to EPA, measurable goals that include these three components and are easy to quantify and allow the permittee and regulatory agencies to assess progress at reducing pollutants to the MEP. The City and their co-permittees include 33 BMPs and 46 measurable goals in the Joint SWMP (Table 10).

Table 10. Number of BMPs and Measurable Goals in the Joint SWMP.

Minimum Control Measure		Number of BMPs	Number of Measurable Goals
MCM 1:	Public Education and Outreach	6	8
MCM 2:	Public Involvement and Participation	4	7
MCM 3:	Illicit Discharge Detection and Elimination	5	8
MCM 4:	Construction Stormwater Runoff Control	7	7
MCM 5:	Post-Construction Stormwater Management in New Development and Redevelopment	6	10
MCM 6:	Pollution Prevention and Good Housekeeping for Municipal Operations	5	6
	Total	**33**	**46**

3.3.2 MCM Assessment Summaries

The aim of this assessment was to evaluate the City's recent and on-going efforts with respect to maintaining compliance with the MS4 permit requirements. Although the County and MU play a vital role in meeting the obligations of the MS4 permit, the sections that follow primarily focus on the efforts undertaken by the City. Summaries of the findings of the assessment for each of the six MCMs are provided in the following sections. Each of the summaries also includes additional information on EPA's goals and guidance for the respective MCM.

<u>MCM1 – Public Education and Outreach</u>

EPA suggests that permittees inform individuals about steps that can be taken to reduce stormwater pollution by developing outreach and communication strategies that are tailored to the community. Example strategies include brochures or fact sheets, public service announcements, interactions with community groups, implementing educational programs, and leading community-based projects such as storm drain stenciling, and watershed cleanups. EPA also recommends that some of the materials or outreach programs be directed toward targeted groups of commercial, industrial, and institutional entities likely to have significant storm water impacts.

Based on review of the recent annual reports, the City, in collaboration with the County and MU, has completed several outreach and education activities in compliance with the permit requirements, including: identification of pollutants of concern, development of numerous brochures, webpages, workshops, stream cleanups, special projects, TMDL demonstration/education, grant-funded stormwater retrofits with related education, partnership meetings, and education visits to concrete companies. Measures of success include quantification of litter cleaned up and the number of volunteers participating in clean-up events. The City appears to significantly engage in activities that reach multiple audiences. For example, the 2012 annual report states that over 4,000 citizens had some type of direct contact with the Stormwater Outreach program during nearly 100 separately documented events. As previously noted, the City also maintains a website for the City's Stormwater Program and is active on social media.

MCM2 – Public Involvement/Participation

Public involvement is a key component of storm water management programs. Ideally, this public involvement should include engaging individuals from a variety of economic and ethnic groups to provide input in developing, implementing, and reviewing storm water management programs. There are many options to include citizen stakeholders as part of the process. These can range from participation in public hearings, serving on local storm water management panels, assisting to coordinate the local program to activities such as volunteer monitoring or stream clean-up efforts.

The City, along with MU and the County, have completed numerous public involvement and participation events related to public education, such as stream team stream/road clean-ups that have involved thousands of volunteers and several tons of trash removed from the watershed. The following are some additional examples of activities reported under this MCM:

- The CAM process for the Hinkson Creek TMDL began in April 2012.
- The City met twice in 2012 with a Stormwater Advisory Board to address redevelopment in a local ordinance and design manual.
- Stakeholders are involved in the Bonne Femme Watershed Management plan to address bacteria.
- Public Notice requirements for construction projects appear to be in place.

In regard to the CAM, the annual reports indicate the establishment of three specific teams, including a 15-member stakeholder committee, an action team, and a science team. Each team meets six to 10 times per year, and the action team has led the completion of a Geographic Information System (GIS) habitat assessment for Hinkson Creek and its subwatersheds, as well as the implementation of a level spreader[1] BMP performance study.

[1] A level spreader is an erosion control device designed to reduce water pollution by mitigating the impact of high-velocity stormwater surface runoff.

MCM3 - Illicit Discharge Detection and Elimination

EPA recommends that a storm water management program include an illicit discharge detection and elimination component. This component should include procedures such as visual inspections of outfalls during dry weather and field tests of selected pollutants to determine priority illicit discharge areas. Once priority areas are determined a plan for tracing the source of the illicit discharges as well as procedures to eliminate the discharge is needed. The illicit discharge detection and elimination program should be periodically reviewed and revised. This component of a storm water management program can also include education activities such as storm drain labeling and stenciling, public reporting or illicit discharges, and distribution of related outreach materials.

The City has completed GIS mapping of all known outfalls and continues to update this dataset. In accordance with the MS4 permit, the City has adopted ordinances or other administrative controls to deem illicit discharges as illegal and undertake enforcement action, if necessary. The City also has a public reporting hotline for illicit discharges. The reporting of illegal discharges has increased over the first few years of the permit cycle.

Additionally, the City has an active inspection program. Specifically, the City inspects areas where illicit discharges have been reported and also randomly inspects areas when field staff are attending other matters. The City also continues a grease-trap inspection program. The City has embarked on an extensive Sanitary Sewer Evaluation Study (SSES) to detect and eliminate illicit connections to the sanitary sewer, which should also identify cross connections with the storm drainage system or defects adjacent to creeks and streams that have the potential to cause a discharge. The City has completed this work in three basins. Additionally, all building construction and remodeling is inspected to evaluate plumbing and wastewater connections.

In the City, building inspectors are expected to visually inspect for illicit discharge detections when evaluating structures. An opportunity for improvement in this area is to dedicate resources for IDDE and a more strategic proactive visual inspection program through watershed and stream inspections, given the numerous points of potential discharges that cannot be captured through existing pipe inspections or report responses.

MCM4 – Construction Site Runoff Control

Areas undergoing new development or redevelopment should have procedures in place for construction site inspection and enforcement of the necessary control measures. Site inspections can be prioritized based on the type of construction occurring, the local topography, soil and water quality. These inspections should also include an evaluation of consistency with local sediment and erosion control requirements. Requiring construction site storm water pollution prevention plans, for sites in the jurisdiction, can also be included as part of the program. Another option is to provide additional training to local construction site operators as to the appropriate management of storm water runoff from the site.

The City has established required ordinances with enforcement capacity and mechanisms, BMP requirements, Stormwater Pollution Prevention Plan (SWPPP) requirements, site plan review, inspection requirements and related written procedures for all regulated construction projects. Consideration is given to special features such as karst geology. At the City, all private construction and development is handled through the Community Development Department. Four City inspectors and one City engineer became certified in erosion and sediment control inspection. All City public improvement projects are inspected by City personnel.

MCM 5: Post-Construction Stormwater Management in New Development and Redevelopment

By considering water quality impacts in the initial stages of a new development or a redevelopment project, more opportunities for water quality protection can be identified. EPA recommends that the planning process for new development or redevelopment identifies the goals of the municipal storm water management program, implementation strategies, operation and maintenance policies and procedures, and enforcement procedures while considering existing ordinances, policies, programs and study results that address storm water runoff quality. Selection of BMPs for a new or redeveloped sites should be appropriate for the local community, improve water quality, and attempt to maintain pre-development runoff conditions. Locally-based watershed planning efforts which involve a diverse group of stakeholders including interested citizens can aid in the selection of appropriate BMPs for such sites.

Both structural and non-structural BMPs should be considered. Structural BMPs include storage, filtration and infiltration practices. To determine the appropriate implementation of such practices, EPA recommends pre-construction review of BMP designs, inspections during construction to verify BMPs are built as designed, post-construction inspection and maintenance of BMPs, and penalty provisions for the noncompliance with design, construction or operation and maintenance.

Non-structural BMPs (preventative measures that involve management and source controls) should also be evaluated. These non-structural BMPs could include local policies and ordinances focused on directing growth to identified areas (infill development in higher density urban areas and areas with existing infrastructure), protection of sensitive locations, maintaining or increasing available open space, and providing buffers along sensitive water bodies. Other non-structural BMPs can seek to minimize impervious surfaces and the disturbance of soils and existing vegetation.

EPA also recommends that post-construction storm water management programs should include education programs for developers and members of the public regarding ways to design projects to minimize water quality impacts and impervious area. As storm water technologies are continually improving the post-construction stormwater management programs should have a mechanism to be responsive to these changes.

Nationally, this area of the MS4 program, being focused on stormwater quality, has required a stormwater management paradigm shift (for all stakeholders) that is still occurring and ripe for refinement in the goal of significant water quality protection. The approach in the industry has changed from a faster to a slower discharge more like that of the natural processes, while still achieving flood protection. While the co-permittees have amended their stormwater ordinances, policies, BMPs, and processes to incorporate requirements for water quality, discussions continue across the country regarding understanding and implementing strategies and standards that could be most effective for a given region and/or watershed. These discussions include the definition and applicability of design storms, diversity of geological features, effective standards and whether a standard should even exist.

The annual reports include information on retrofit projects and indicate that each of the co-permittees have also modified their manuals and ordinances/policies to expand options for post-construction BMPs. Project review and approval processes are changing to consider water quality in the project-planning stage. Additional and continued BMP performance monitoring specific to this region will inform the continued discussion on effective performance standards and state-of-the-practice.

The City of Columbia Stormwater Management and Water Quality Manual that was adopted in March 2007 allows for stormwater management plans to be tailored to specific conditions in the City's watersheds for both development and redevelopment projects. The manual is continually reviewed and updated as necessary. Additionally, the City's Community Development Department enforces the City's Stream Buffer Ordinance and stormwater quality management for new developments and also records covenants and maintenance agreements for post-construction BMPs.

The City receives and tracks annual inspection information for the post-construction BMPs and maintains this information in a GIS database. The database includes 412 records of known BMPs throughout the City, approximately 50% of which are categorized as bioretention, detention, or ponds (**Figure 3, Attachment G**). Approximately 14% of the BMPs in the database are unknown or not identified and many records are missing basic information such as the owner, descriptions, date of last inspection, and links to pictures. One potential opportunity for improvement is for the City to update the GIS database to reflect the most recent annual inspection information available. These updates would improve the City's ability to track and report progress towards meeting post-construction management requirements.

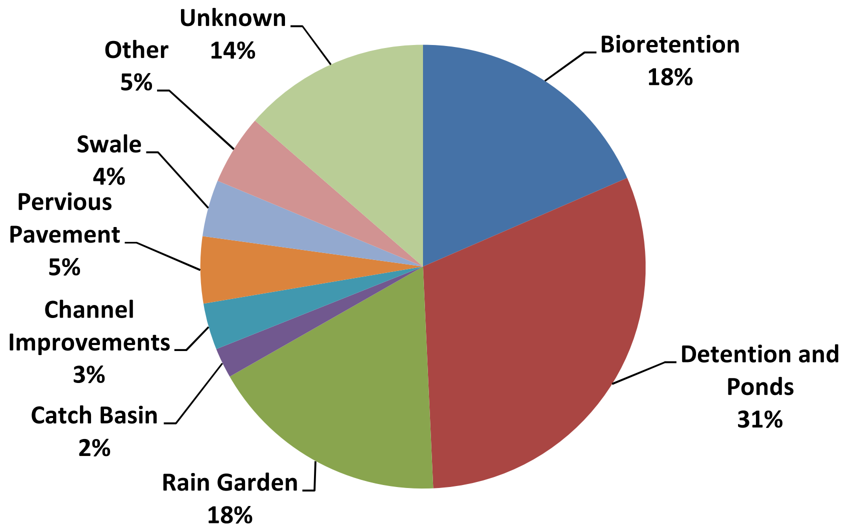

Figure 3. Categories of Structural BMPs (412 Individual Records).

In addition to the activities described above, the 3M wetland and Katy Place trail detention retrofit projects were implemented to treat over 140 acres of upstream development before it enters into Hinkson Creek (Figure 4). The Forum Nature Area Level Spreader Monitoring Project was established through the CAM to assess BMP effectiveness. Additionally, demonstration projects have also been implemented in the City and on the MU campus.

Figure 4. The 3M Wetland and Katy Place Trail Detention Retrofit Projects Treat Over 140 Acres of Stromwater Runoff from Upstream Development.

MCM 6: Pollution Prevention/Good Housekeeping for Municipal Operations

EPA recommends that to reduce the risk of water quality problems, municipal operations and maintenance should be a key component for all municipal storm water management programs. Effective operations and maintenance based pollution prevention programs should consider schedules and activities to ensure limited impacts on water quality. Pollution prevention programs can evaluate existing projects to determine if additional water quality practices are needed, as well as evaluate new flood management projects to assess the impacts on water quality.

Effective and efficient programs should include long-term inspection procedures for both structural and non-structural controls to result in reductions of floatables and other pollutants, controls to reduce or eliminate the discharge of pollutants from roadways, parking lots, storage yards, maintenance shops or yards, salt and/or sand storage locations, snow disposal operations and waste transfer stations. Pollution prevention plans should also contain procedures for the disposal of waste such as dredge spoils, accumulated sediments, floatables, and other debris removed from separate storm sewers and any of the areas listed above.

All co-permittees have staff training and inspection requirements. Existing spill prevention programs have been incorporated. Quantification of street sweeping and staff training is evident in the annual reports.

3.3.3 Stormwater Quality Performance Summary

The assessment of the City's MS4 permit compliance efforts reveals that the City has dedicated a significant amount of resources to maintain compliance with the permit requirements. While opportunities for improvements and increased efficiencies exist, the City's efforts, as represented by the previous annual reports, are fulfilling the requirements of the permit.

- **MCMs 1: Public Education and Outreach and MCM2: Public Involvement and Participation –** The City develops and implements publications, events, and training, and has added awareness and involvement through the Hinkson Creek Urban Retrofit Project and CAM process, as well as other watershed groups and special projects.
- **MCM 3: IDDE –** The City has mapped their known outfalls, adopted ordinances or other administrative controls to reduce illicit discharges, and has an active inspection program. One opportunity for impromement includes pursuing a more strategic and proactive visual inspection program.
- **MCM 4: Construction Stormwater Runoff Control –** The City has established ordinances with enforcement capacity and mechanisms, performs erosion and sediment control inspections, and provides project oversight.
- **MCM 5: Post-Construction Stormwater Management in New Development and Redevelopment –** The City has completed several retrofit projects, enforces ordinances and development requirements, and tracks BMPs. Opportunities exist with respect to further refining standards and BMP design requirements and improving BMP data management.
- **MCM 6: Pollution Provention/Good Housekeeping for Municipal Operations –** The City incorporates staff training requirements, inspection requirements, spill prevention programs into their program. Additional consideration might be given to a more dynamic and inclusive inspection program with independent quality checks (including government/MU construction projects).

Section 4. Existing Stormwater Utility Needs

To develop a better understanding of funding needs relative to the existing system condition and performance, the project team broadly reviewed planned capital improvement program (CIP) projects, costs, and current funding levels. Results are summarized in the following sections.

4.1 Current Stormwater Capital Improvement Program Funding

The City's fiscal year (FY) 2017 capital improvement program (CIP, Columbia 2016) stormwater projects include infrastructure asset management, flood reduction projects and stormwater runoff water quality improvements. It is anticipated that with the large amount of CMP in the system, asset management needs will increase over the next 20 years and exacerbate the stormwater funding issues already facing the City. For example, the 2008 Stormwater Utility Assessment identified an annual expenditure of $5.8 million for CMP replacements starting in year 2010 and continuing for approximately 10 years until the asset management portion would drop to approximately $2.8 million (CH2MHill 2008). The current level of asset management investment is less than 10% of what was projected by the 2008 Stormwater Utility Assessment report (CH2MHill 2008). It is clear that with the resources currently available, necessary system replacement and renewal activities must be deferred. This deferment will result in a reduction in system reliability and an increase in emergency repairs. To help address these issues, more detailed renewal costs and alternatives will be evaluated in the next phase of the IMP process.

4.2 Current Stormwater Prioritization Method

Due to budget shortfalls outlined in the previous section, there are multiple flood and erosion reduction needs that cannot currently be addressed. As a result, City staff uses a holistic approach to prioritize funding expenditures which is generally based on public safety and impacts to infrastructure (**Table 11**). The prioritization method is weighted to promote projects that reduce the flooding risk exposure to the traveling public. For instance a failing CMP below a highly traveled street would rate much higher than flooding damages to a single residence. If the CMP was also undersized, then the points available would include Safety (150 pts), Street Flooding (80 pts) and Maintenance (40 pts). A single structure flooding problem would be eligible for 10 pts plus the years waiting points.

There are multiple challenges when developing and applying a prioritization method. It is suggested that the prioritization method closely align with community priorities which will shift over time and after major events such as a system failure in a well traveled street. It is recommended that the City periodically request community input and revise the existing prioritization methodology appropriately. Community input could be obtained through individual outreach events or through a more structured approach like a Stormwater Utility advisory board.

Table 11. Existing Stormwater Project Prioritization Approach.

Criteria	Points Available	Weighting	Decision Criteria
Years Waiting	30	8%	Up to 5 years of waiting scores zero points. 30 or more years of waiting will score the highest points.
Safety	150	38%	Related to a structural failure leading to safety concerns.
Structure Flooding	10	3%	Water in doors and windows will score the highest points. Basement flooding scores 1 point. Each flooded structure will receive points.
Street Flooding	80	20%	Based on size of roadway and depth in street. 100 pts is added if a car can be swept from the road or the road is the single point of access for a neighborhood.
Yard Flooding	5	1%	Maximum score when it threatens house or garage.
Erosion	40	10%	Maximum score if the erosion will impact house, utilities or street. Add 50 pts if the erosion also impacts the stormwater system.
Maintenance	40	10%	Higher points are awarded if a sinkhole is forming.
Permitting	40	10%	Scores 40 or zero based on additional agreements and permits being needed.

Section 5. Summary

The stormwater system evaluation findings and summary points are as follows:

- The City records a significant amount of data on their stormwater lines and pipes in their GIS system. The database indicates that the City owns and maintains approximately 175 miles of pipes and 14,000 structures. Approximately 50% of both the pipes and structures have been installed in the last 15 years.

- The overall condition of the stormwater system is largely unknown; approximately 1% of the pipes and 7% of the structures have been inspected and assigned a condition rating.

- According to the data, CMP makes up more than 33% of the system. Approximately 128,000 feet of CMP is more than 30 years old and would be expected to have sections of structurally deficient pipe. In the next 10 years, the length of CMP beyond the useful life will approach 225,000 feet.

- Flooding reports (2,670 total) are widespread throughout the City and the severity and impact of the flooding varies. There are several areas in the City with a relatively high concentration of flooding reports.

- The City's Stormwater Management & Water Quality Manual (Columbia 2009) is robust, has been recently updated, and is easily accessible for the public and private land developers. The City may want to consider reevalutating key design standards, such as assumed temporal storm distributions, to increase stream channel protection during wet weather.

- The City's stormwater management efforts indicate that they are protecting water quality through the application of BMPs and measureable goals to the maximum extent practicable, as is required by the MS4 permit. Specific conclusons for each MCM and opportunities for improvement are outlined in Section 3.3.3.

- The current level of asset management investment is less than 10% of what was projected by the 2008 Stormwater Utility Assessment report (CH2MHill 2008). It is clear that continued underfunding and deferment of system replacement and renewal activities will result in a reduction in system reliability and an increase in emergency repairs.

- The City relies on a project prioritization approach that is generally based on public safety and impacts to infrastructure. The City could potentially improve the methodology by periodically requesting community input through individual outreach events or through a more structured approach like a Stormwater Utility advisory board.

A number of data gaps and limitations were also identified while reviewing the stormwater system database. Addressing these gaps will help improve future stormwater system planning, maintenance, and performance. The City is aware of many of these issues and is currently working to improve their data collection, tracking, and maintenance procedures.

- **Flooding Report Database Formatting –** To improve mapping and analysis efficiency, consistent data formatting is needed throughout the report database. In particular, addresses or other coordinates should be entered for each per report report and a standard format (e.g., house number followed by street name) should be applied. Flooding reports that are associated with specific locations will aid in capital improvement planning, risk assessment and other analyses of flooding, erosion, and city-wide observations.

- **Stormwater Maintenance Database –** Currently, the City's stormwater system includes very little cleaning, maintenance, or condition information. Collecting, analyzing, and maintaining this type of information would help the City work to efficiently maintain existing stormwater assets and proactively address vulnerable areas rather than respond reactively system failures and emergency situations. Keeping a database and system that includes stormwater line information such as cleaning dates, line conditions; completed closed circuit television inspections (CCTV) and other inspection data would support the necessary planning and analysis efforts. Stormwater CCTV inspections are an annual unfunded request.

- General missing attribute information of the Stormwater database includes:
    - Approximately 30-percent of the stormwater lines and structures have an unknown construction year.
    - Approximately 12-percent of the records have an unknown pipe size
    - 99-percent of the records are missing invert information.

Section 5. References

Boone County Resource Management/Columbia Public Works Department/MU Department of Environmental Health and Safety (Boone County/Columbia/MU). 2015. Show-Me Stormwater Management: Joint Stormwater Management Program. Revised December 2015. https://dnr.mo.gov/env/wpp/permits/ms4swmp/docs/0136557_2015_SWMP.pdf

City of Columbia (Columbia). 2016. FY 2017 CIP Planning Document. Finance Department – Accounting Division. Columbia, MO. October 1, 2016. https://www.como.gov/finance/wp-content/uploads/sites/21/2015/11/FY-2017-Draft-Document-March-2016-1.pdf

City of Columbia (Columbia). 2009. Stormwater Management and Water Quality Manual. Public Works Department. Columbia, MO. Revised January 2015. https://www.como.gov/PublicWorks/StormWater/stormwater-manual.php

CH2MHill. 2008. Technical Memorandum #4: City of Columbia Stormwater Utility – Financial Model Results for Two Rate Scenarios. Project Number 363740. https://www.como.gov/PublicWorks/StormWater/2008StormwaterUtilityAssessment.php

Huff, F., and J. Angel. 1992. Rainfall Frequency Atlas of the Midwest. Bulletin 71, Midwestern Climate Center. MCC Research Report 92-03.

Missouri Department of Natural Resources (MDNR). 2016. Missouri State Operating Permit MO-0136557). Missouri Clean Water Commission. Jefferson City, MO. http://dnr.mo.gov/env/wpp/permits/issued/docs/0136557.pdf

Perica, S., Martin, D., Pavlovic, S., Roy, I., St. Laurent, M., Trypaluk, C., Unruh, D., and Yekta, M., Bonnin, G. 2013. NOAA Atlas 14 Volume, Precipitation-Frequency Atlas of the United States Version 8 Midwestern States. OAA, National Weather Service, Silver Spring, MD. http://www.nws.noaa.gov/oh/hdsc/PF_documents/Atlas14_Volume8.pdf

USDA-NRCS. 2015. National Engineering Handbook: Chapter 4 Storm Rainfall Depth and Distribution. NEH Part 630.04. September 2015 (Draft). http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/water/?cid=stelprdb1043063

US Environmental Protection Agency (EPA). 2001. Measurable Goals Guidance for Phase II Small MS4s. Office of Water. Washington, DC. https://www3.epa.gov/npdes/pubs/measurablegoals.pdf

Technical Memorandum 4

Attachments

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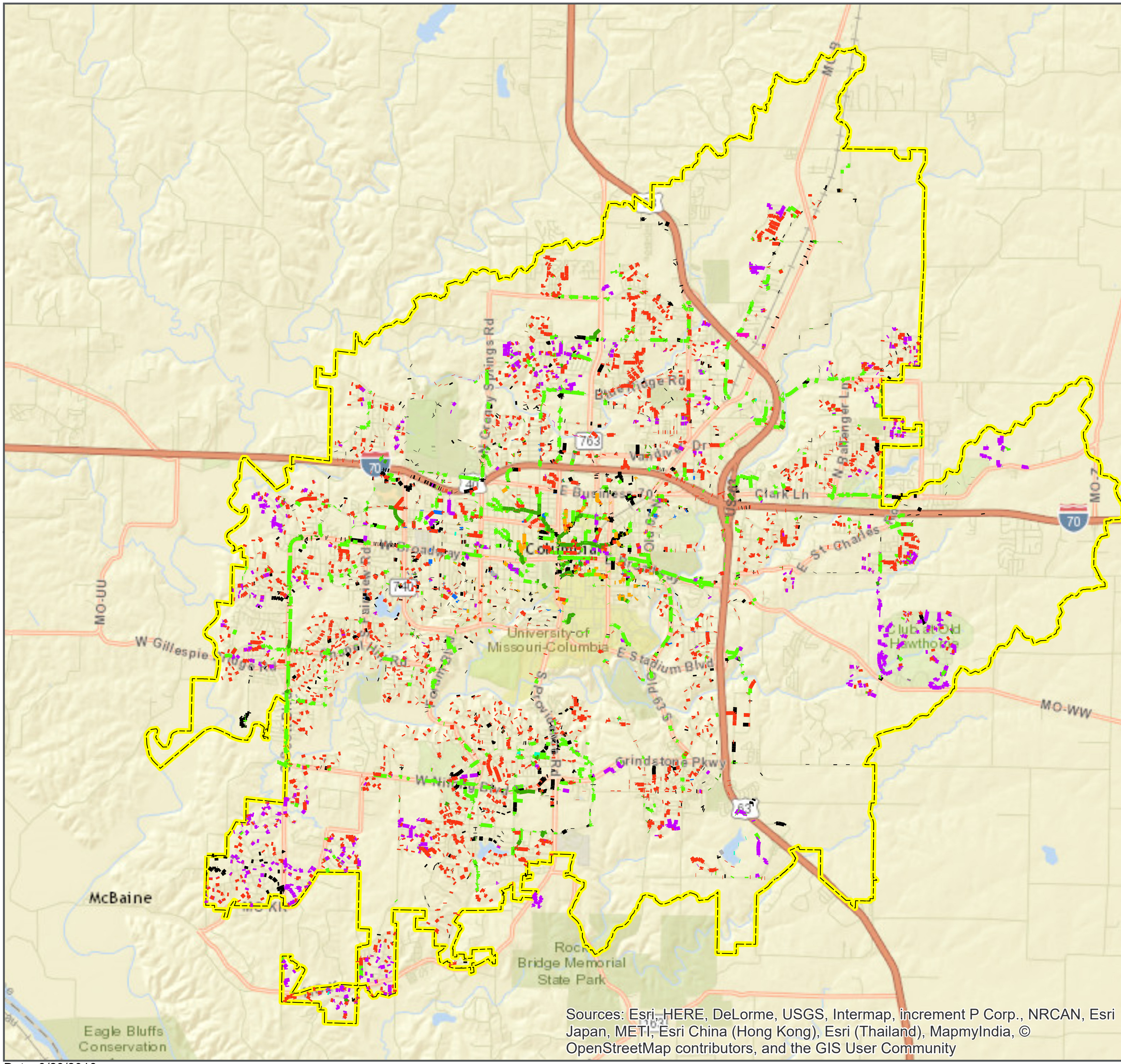

Our Columbia Waters
Integrated Management Plan
Wastewater & Stormwater

Legend

Urban Service Area

Material

- CMP
- CPEP
- CPP
- HDPE
- BCCMP
- PVC
- RC
- RCP
- VCP
- Unknown

ATTACHMENT A
STORMWATER PIPE INVENTORY

CITY OF COLUMBIA
MISSOURI

WASTEWATER & STORMWATER INTEGRATED MANAGEMENT PLAN

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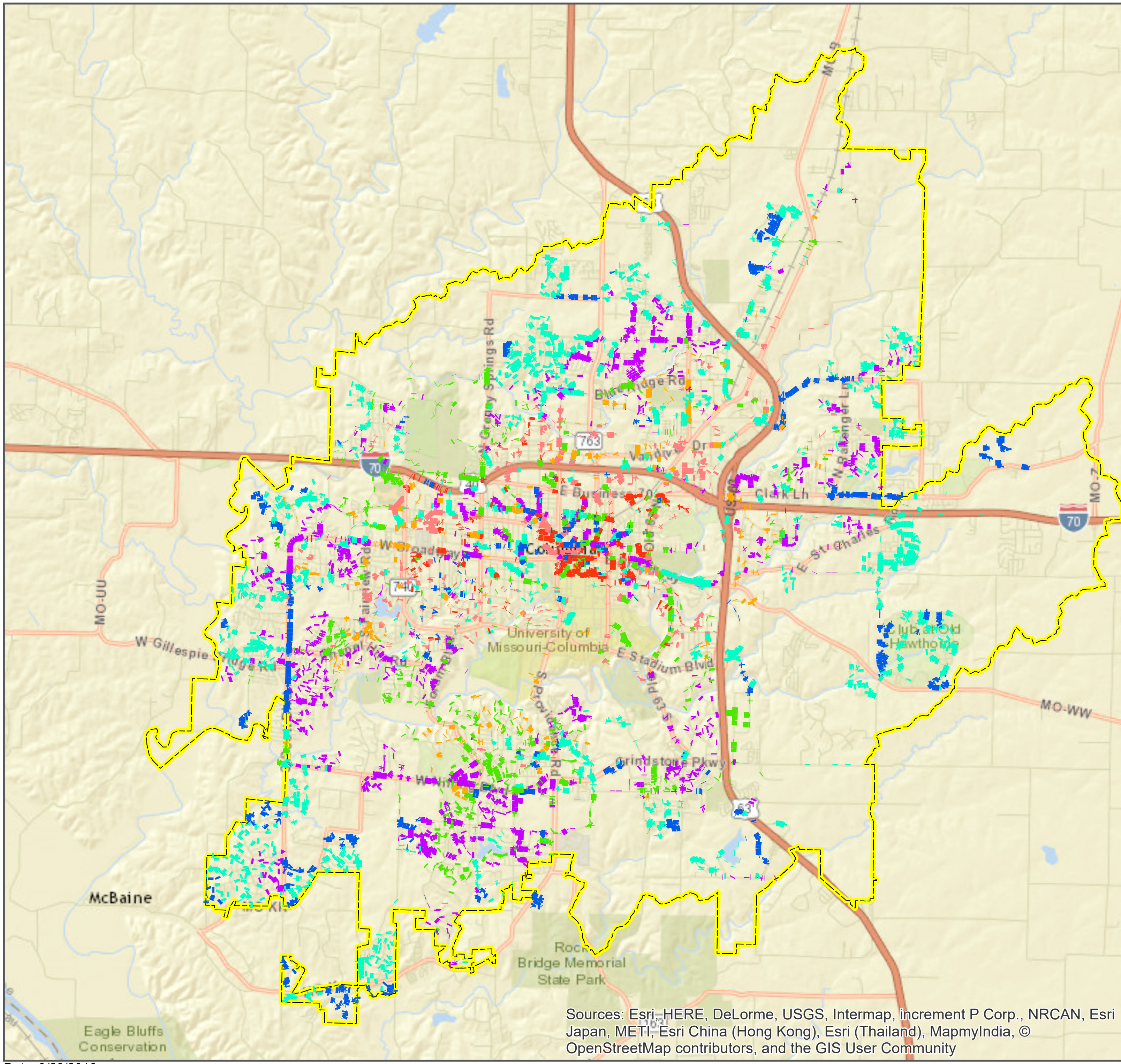
Date: 9/23/2016



Our Columbia Waters
Integrated Management Plan
Wastewater & Stormwater

Legend

Urban Service Area

Construction Year

- Pre-1960
- 1960-1970
- 1970-1980
- 1980-1990
- 1990-2000
- 2000-2010
- 2010-Present

ATTACHMENT B
STORMWATER PIPE INVENTORY BY AGE

CITY OF COLUMBIA
MISSOURI

WASTEWATER & STORMWATER INTEGRATED MANAGEMENT PLAN

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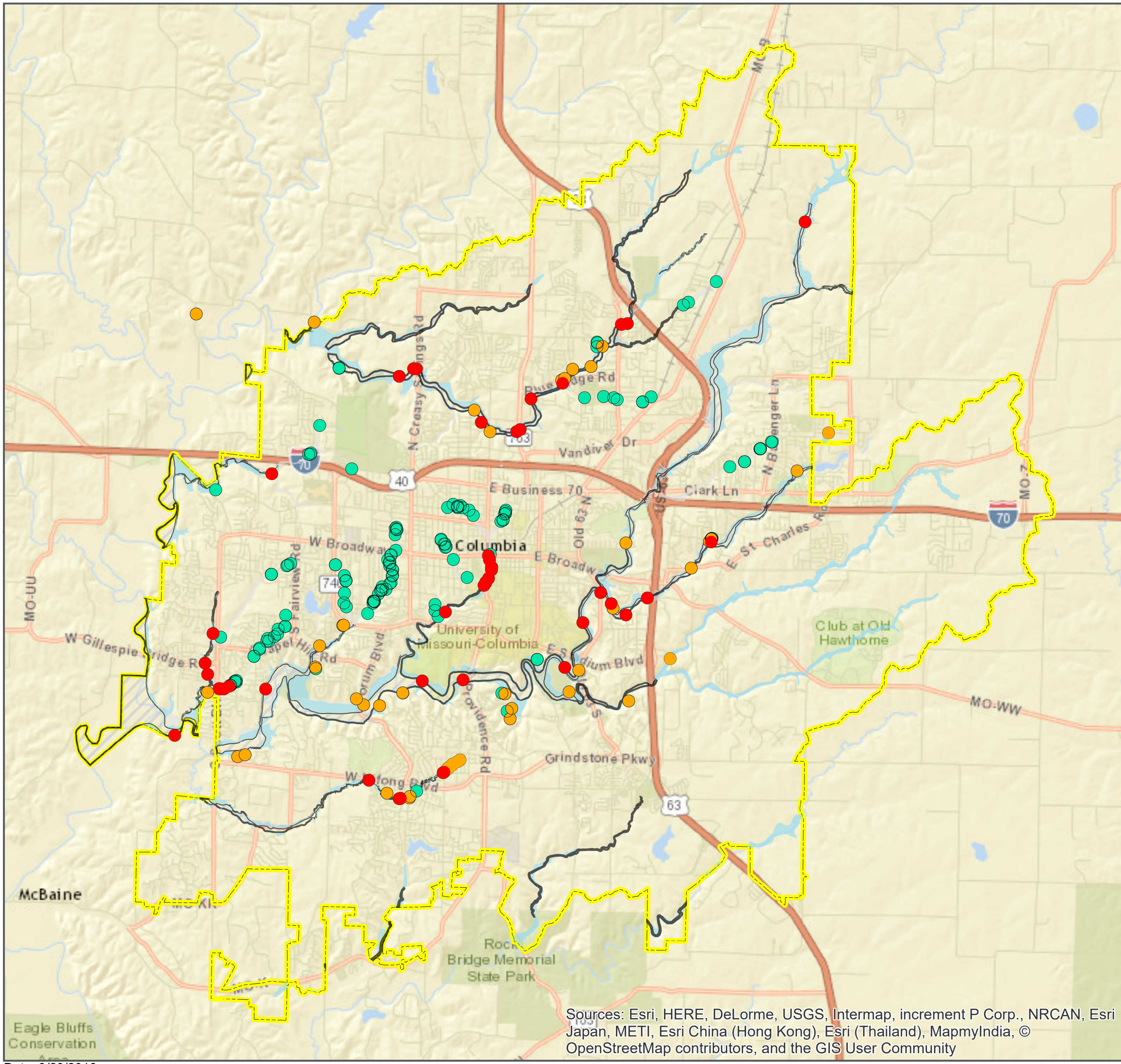

Date: 9/23/2016

Our Columbia Waters
Integrated Management Plan
Wastewater & Stormwater

Legend

Urban Service Area

Reported Flooding Locations

- Floodway
- Floodway Fringe
- 500 Yr. Annual Chance Flood Hazard

Regulatory Floodplain

- Floodway
- Floodplain

ATTACHMENT C
RIVERING FLOODING

CITY OF COLUMBIA
MISSOURI

WASTEWATER & STORMWATER INTEGRATED MANAGEMENT PLAN

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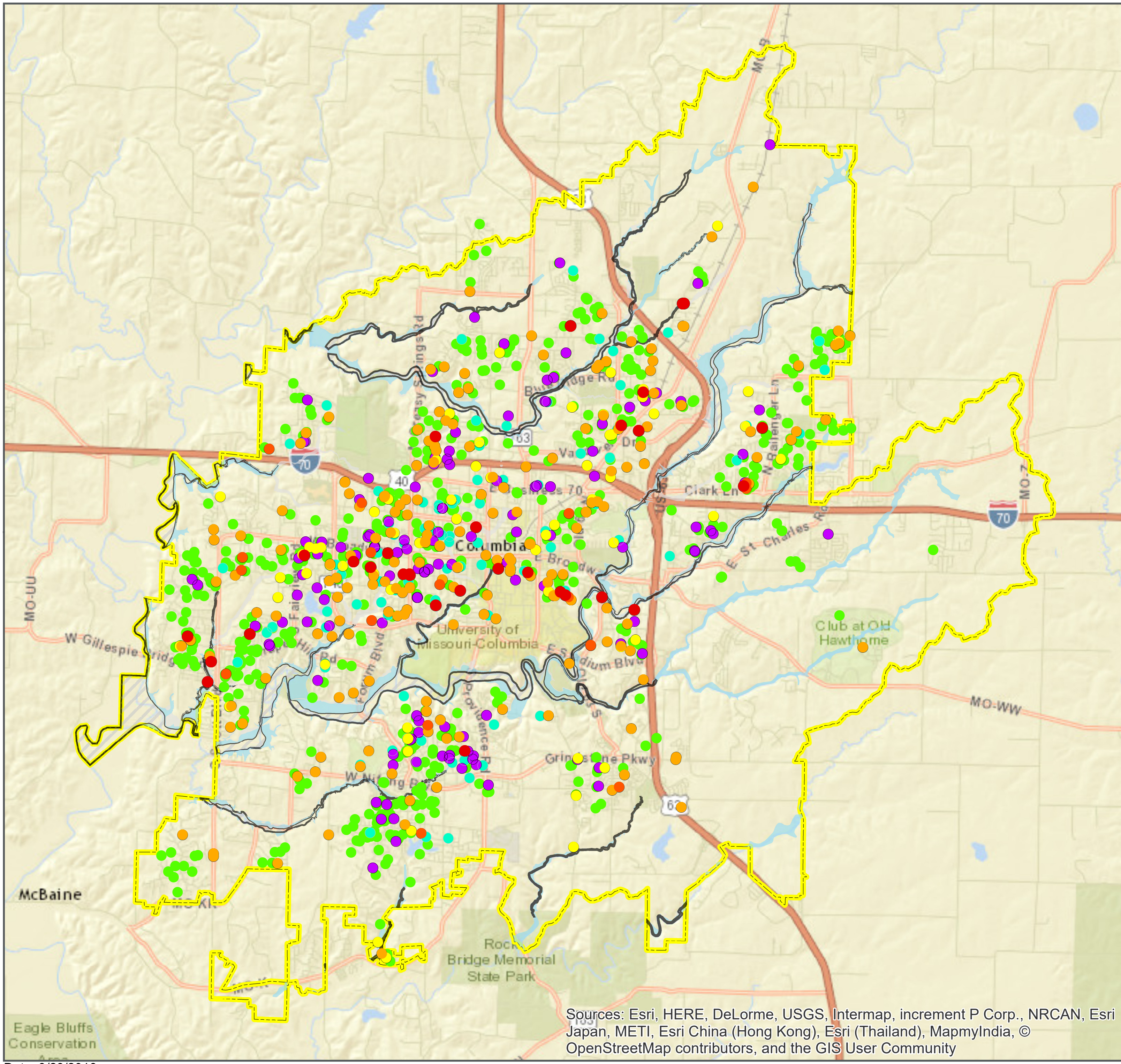

Our Columbia Waters
Integrated Management Plan
Wastewater & Stormwater

Legend

Urban Service Area

Regulatory Floodplain

Floodway

Floodplain

Reported Flooding Locations

- House, Yard, & Street
- House & Street
- Street Flooding Only
- Yard & Street
- House & Yard
- House Only
- Yard Only

ATTACHMENT D
STREET, HOUSE & YARD FLOODING

CITY OF COLUMBIA MISSOURI

WASTEWATER & STORMWATER INTEGRATED MANAGEMENT PLAN

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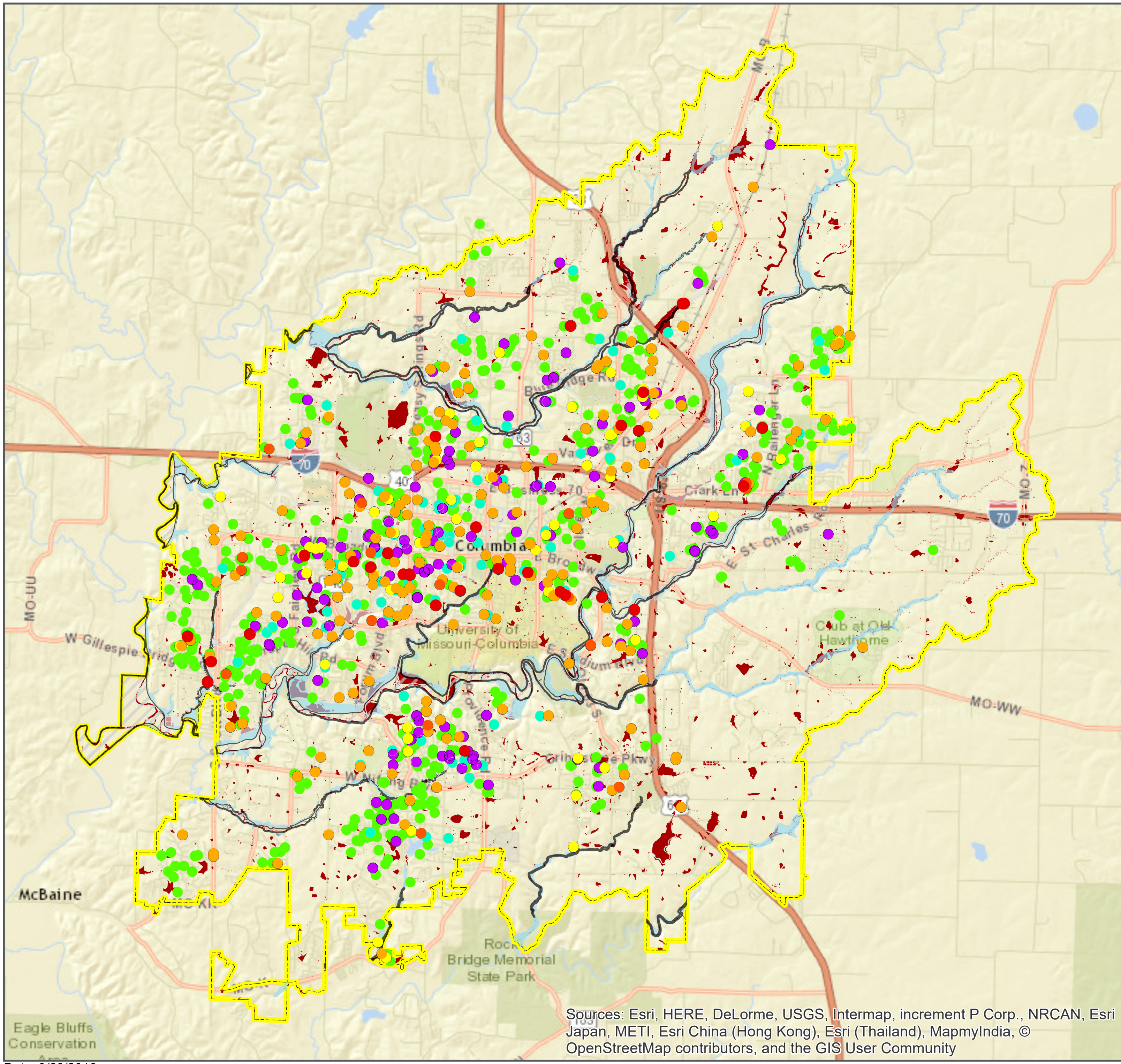

Date: 9/23/2016

Our Columbia Waters
Integrated Management Plan
Wastewater & Stormwater

Legend

Urban Service Area

Depression Areas

Regulatory Floodplain

Floodway

Floodplain

Reported Flooding Locations

- House, Yard, & Street
- House & Street
- Street Flooding Only
- Yard & Street
- House & Yard
- House Only
- Yard Only

ATTACHMENT E
DEPRESSION AREAS & REPORTED FLOODING LOCATIONS

CITY OF COLUMBIA MISSOURI

WASTEWATER & STORMWATER INTEGRATED MANAGEMENT PLAN

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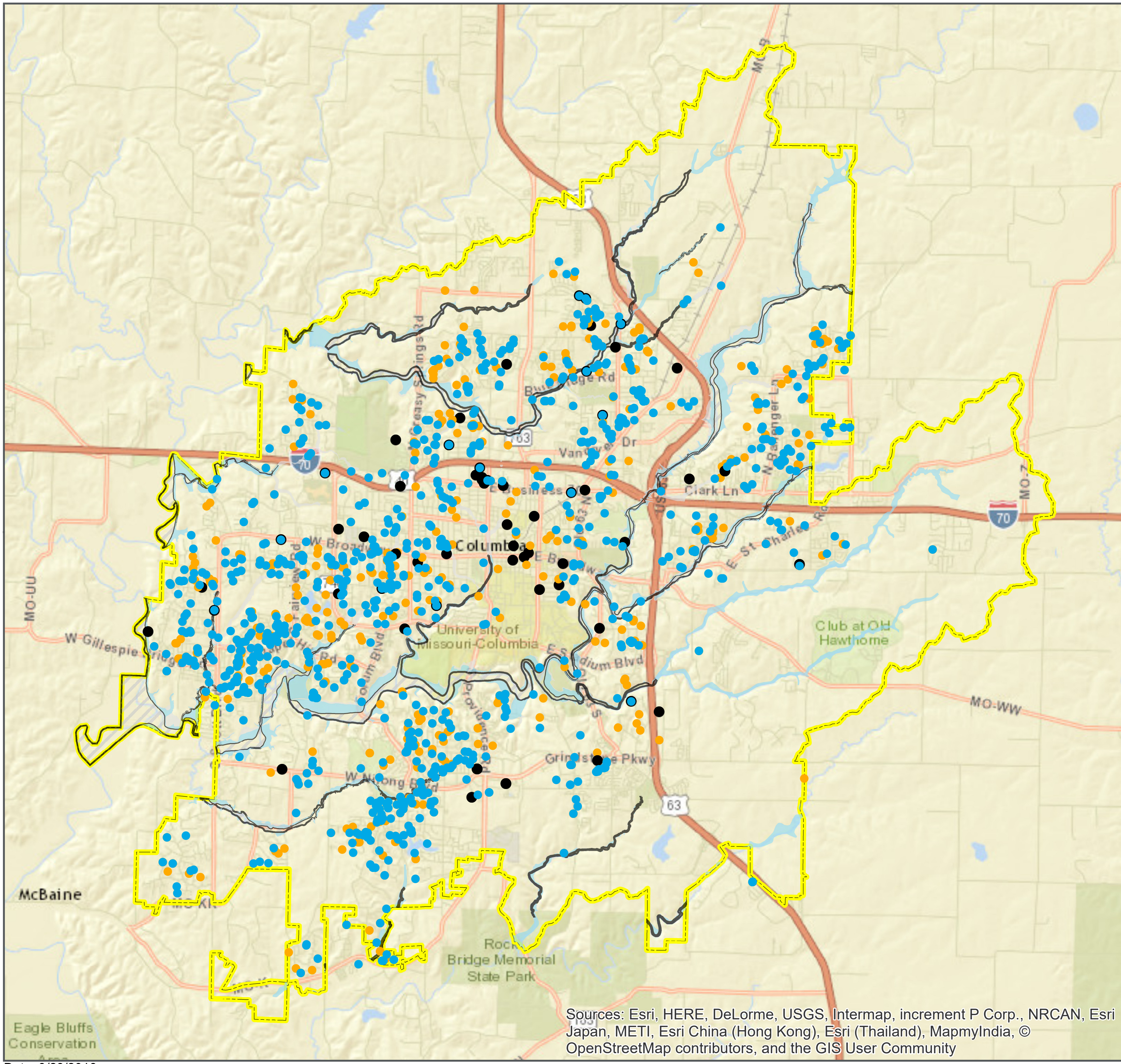

Our Columbia Waters
Integrated Management Plan
Wastewater & Stormwater

Legend

Urban Service Area

Depression Areas

Regulatory Floodplain

Floodway

Floodplain

Reported Locations

Open Channel

Failing System

Reported Yard Erosion

ATTACHMENT F
OTHER CITIZEN REPORTS

CITY OF COLUMBIA
MISSOURI

WASTEWATER & STORMWATER INTEGRATED MANAGEMENT PLAN

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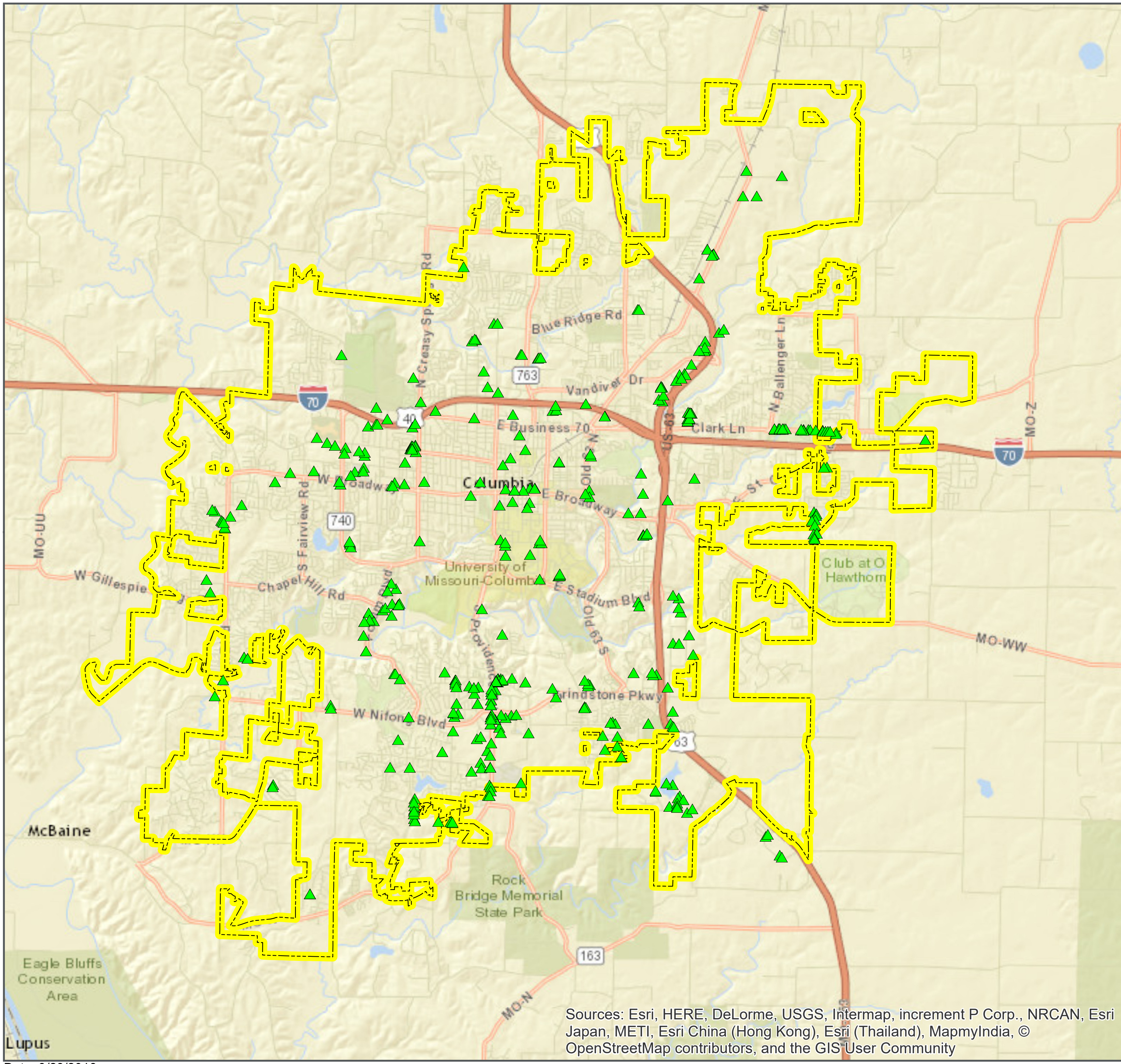
Date: 9/23/2016



Date: 9/23/2016

Our Columbia Waters
Integrated Management Plan
Wastewater & Stormwater

Legend

Stormwater BMP

Columbia City Limit

ATTACHMENT G
STORMWATER BMP LOCATIONS

CITY OF COLUMBIA MISSOURI

WASTEWATER & STORMWATER INTEGRATED MANAGEMENT PLAN

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Columbia Wastewater and Stormwater IMP

Attachment I

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Our Columbia Waters
Integrated Management Plan
Wastewater & Stormwater

Community Outreach Plan

Columbia Wastewater and Stormwater Integrated Management Plan

Columbia, Missouri
September 13, 2016

HDR

Shockey Consulting Services, llc

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Table of Contents

Section 1. Plan Purpose

The Community Outreach Plan for the Integrated Management Plan for Wastewater and Stormwater (IMP) defines the process to involve the community in the decision-making process. The approach is to bring people from the community together, educate them regarding the various issues and gather input in a structured, inclusive and transparent process.

A variety of methods for communicating with the community are described and will be coordinated appropriately with ongoing technical activities.

This document includes:

- an overview of the project
- the objectives for communication and public involvement
- key messages
- the strategic approach for communication and public involvement
- methods of communications

Section 2. Project Overview

The process will result in an IMP that provides a means to implement currently planned, critical infrastructure projects over the next five years and sets the City up to successfully plan for and meet long-term environmental and infrastructure goals.

Desired Outcome: An adaptive and flexible plan that provides regulatory certainty and prioritizes affordable investments, which are supported by community stakeholders.

Section 3. Objectives for Community Outreach

Early and continuous community outreach brings diverse perspectives and values into the decision-making process. The objectives for communication and public involvement include:

- *Develop* an informed group of stakeholders that understand the benefits and strategies of implementing available wastewater and stormwater management strategies.
- *Inform* the stakeholders by providing balanced and objective information to assist them in understanding the problems, alternatives, opportunities, and solutions.
- *Consult* the stakeholders by obtaining feedback on water quality and infrastructure priorities and desired outcomes.
- *Involve* the stakeholders by working directly with them throughout the process to ensure that concerns and aspirations are consistently understood and considered, ensuring stakeholder groups are included and consulted.
- *Build* partnerships with other agencies and stakeholders, recognizing the effect this effort has on the community and other sustainable infrastructure initiatives.

Community input will be solicited on public health and safety concerns in addition to environmental issues. Outreach efforts will focus on getting high-level, value-based input from the community. The process will result in an Integrated Management Plan that incorporates the community values and is accepted by the public.

Section 4. Key Messages

A primary component of our approach is to craft consistent messages to engage community stakeholders throughout the course of the process. The project team will work with City staff to review and approve the messages.

The messages will explain the Vision, Outcomes and Approach for the plan to create understanding and encourage participation.

4.1 Vision Statement

The stormwater and wastewater Integrated Management Plan is a community-driven, affordable infrastructure plan that enhances human health, safety, water quality, economic vitality and environmental resources by leveraging our existing assets and implementing innovative solutions.

4.2 Outcomes

The IMP will detail how the community will, through targeted investments in the wastewater and stormwater programs:

- Improve water quality
  - Mitigate human activity on the environment
- Protect public health & public safety
  - Reduce sanitary sewer overflows
- Reduce property damage due to backups into buildings.
  - Targeted investment improves reliability of system
- Connect people to their environment
  - Create and protect wildlife habitat and recreational amenities
- Protect investment made by properly maintaining system (address aging infrastructure)
- Develop sustainable and affordable infrastructure for future generations

4.3 Approach

During the development of the Integrated Management Plan, stakeholders will take the following approach:

- Innovate – explore ways to use the latest technology & create multiple benefits for each dollar invested
- Collaborate – build partnerships and community support
- Prioritize – develop priorities for scarce community resources & create an affordable plan
- Plan – be forward thinking and create solid capacity to accommodate redevelopment and growth
- Reinvest – renew existing system through strategic investments

Section 5. Project Identity

To maintain continuity and recognition, the project will have a unique identity but follow the brand guidelines for the City of Columbia.

Section 6. Topics Where Input is Needed

The technical team will evaluate and present information about the questions below in order to develop the IMP. They include:

1. How do we want to use our water bodies?
2. What are our water quality priorities? What are the highest priority water quality and regulatory issues?
3. What issues are important to the community? (septic systems, backups into buildings, streambank degradation, flood damage reduction, street flooding, sanitary sewer overflows, neighborhood appearance, property values)
4. How do the potential investments impact user rates and are the impacts equitable?
5. What investments are the highest priority to achieve goals while maintaining affordable rates? What does the City need to do to be sustainable?

Section 7. Targeted Audiences

The following is a listing of the audiences to involve in the IMP development. See Appendix A for a complete list of stakeholder groups.

7.1 Project Team

The Project Team will include staff from the City of Columbia, Missouri, the technical team (led by HDR), and the community outreach team (led by Shockey Consulting Services).

7.2 Key Stakeholders

Key stakeholders from a balance of interests will consider technical information from a community perspective to develop a set of recommendations. These recommendations will guide the Project Team in the creation of the Integrated Management Plan.

The proposed stakeholders below reflect neighborhood, environmental, social, and business-oriented groups that could be included to get a wide variety of input in the process. Specific organizations include:

- Missouri Department of Conservation
- Columbia Audubon Society
- Missouri River Relief
- Sierra Club
- Hinkson Collaborative Adaptive Management Stakeholders
- Friends of Rockbridge Memorial State Park
- PedNet
- Downtown Columbia Leadership Council
- Columbia Chamber of Commerce
- Lawn Care Companies
- Local Industry
- Local Developers and Construction Companies
- Local engineers
- Central Missouri Community Action Center
- Churches
- Central Missouri Opportunity Council
- University of Missouri
- League of Women Voters of Columbia-Boone County
- Neighborhood Associations and Home Owners
- Columbia Housing Authority
- US EPA
- MDNR
- Boone County Regional Sewer District
- Boone County Health Department
- NAACP
- MODOT Diversity Council
- MS4 Coordinating Committee
- Downtown Infrastructure Council

These proposed stakeholders will be invited to participate in a series of community workshops. Fact sheets will be distributed to them to share with the groups they represent. A community questionnaire will be included to gather further input. The project team will offer to give presentations at the regular meetings of these groups asking for input into the plan and letters of support for the draft plan.

7.3 City Officials, City Committees & Key Staff

The Columbia Mayor & City Council will ultimately approve the Integrated Management Plan. At the request of City staff, they will be briefed throughout the process so they can be informed about the planning process and speak with their constituents about it.

Fact sheets will be provided to all City Council members regarding the project. The Columbia City Council will be notified about community workshops and public meetings via the council Current Events email, so that they can listen to the discussions if interested. Meeting agendas and summary notes will be provided to them as well, to keep them informed.

Other City of Columbia committees will be briefed as needed. City of Columbia staff members and/or project team members will make presentations to these groups at their regular meetings. Members of key City committees will be invited to attend the community workshops and public meeting, take the community questionnaire online and receive the fact sheets via email.

Key staff members from the City Manager's office, Development & Planning, the City's Sustainability Officer and others in addition to staff from the wastewater and stormwater programs will be invited to participate in the planning process.

7.4 Other Government Agencies

The Environmental Protection Agency and the Missouri Department of Natural Resources are the regulatory agencies for water quality and therefore, have an interest in the outcome of this work.

The Missouri Department of Conservation may have an interest because of the Eagle Bluff Conservation Area.

Boone County Regional Sewer District, the MS4 Coordinating Committee, and Boone County Health Department all have an interest in the outcome and may want more information to share and show support for the plan.

7.5 Economically and Socially-Disadvantaged Populations

Economic and socially-disadvantaged populations are typically underrepresented but impacted by public policy decisions regarding water. As a part of the City of Columbia's Strategic Plan for 2016-2019, the City has identified three priority neighborhood areas as a focus for achieving social equity. The Interfaith Council for Social Equality, the NAACP, MoDOT Diversity Council will also be engaged in the process. The Columbia Housing Authority could also help distribute information to their contacts.

The Project Team will work with other city initiatives to use existing communication lines to engage these key stakeholders.

7.6 Environmental and Conservation Groups

There are many environmental and conservation organizations in Columbia. As advocates, they have interested members are already working to protect waterways and will provide important input into the community's environmental priorities.

7.7 Business and Development Community

Wastewater and stormwater infrastructure is needed so that business and development can thrive in Columbia. There are many groups in Columbia that represent business and development interests. There are also construction firms and consulting engineers who design and build in Columbia who are knowledgeable about wastewater and stormwater infrastructure.

7.8 Nonprofit Organizations and Other Community Groups

There are many nonprofit organizations and other community and civic groups that represent a cross-section of Columbia's citizenry.

7.9 Large Impervious Surface Property Owners

Institutions such as churches and schools with a large amount of impervious surface generate stormwater runoff and therefore, have an interest in water quality protection and stormwater infrastructure.

7.10 Property Owners Who Have Experienced Chronic Backups into Buildings

There are several areas of town where property owners experience chronic basement backups either from problems on their property or with the public sewer system. They have an interest in investing in the wastewater system.

7.11 General Public/Ratepayers

Any interested party should have the opportunity to become informed about the IMP and provide input into the recommendations. Public notice will be provided prior to the community workshops. Agendas and meeting summaries will be posted on the City's website. Public notices of the community workshops will be posted. The City's Neighborhood Associations and Home Owners Associations leaders will also be notified. Website, social media outlets, and notices on government access channels will be used to notify the general public about the planning process and encourage participation in the community workshops.

7.12 Media

Water quality and infrastructure issues are of major interest to the public and therefore to the news media. Columbia Public Information staff will be the media liaison during the planning process. Stories will be pitched and press releases will be issued regarding progress on the plan and announcements for community workshops. Fact sheets, agenda packets and meeting notes will be provided to beat reporters. The media editors will also be briefed early in the process.

Section 8. Methods

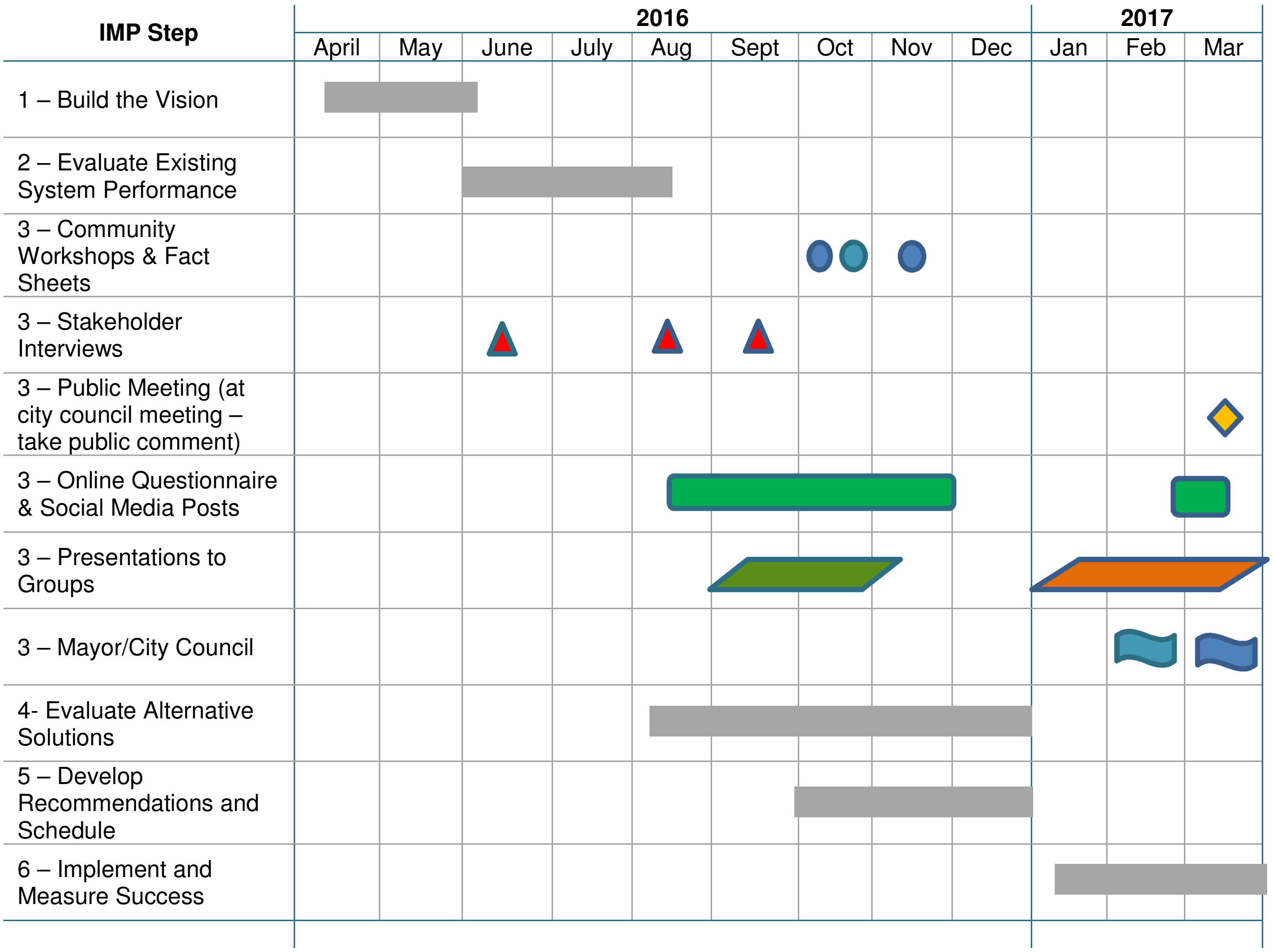
A variety of methods may be used to communicate our messages to the targeted audiences. Two-way communication methods will allow for stakeholders to provide input. With one-way communication methods, information will be provided with the purpose of informing. Potential communications methods may include, but are not limited to, the following:

- **One-Way Communication**
    - Fact sheets
    - Media releases
    - Materials posted on the City's website & a project website at ourcolumbiawaters.com.
    - City's newsletter and Community Development's Neighborhood Newsletter
    - City of Columbia television channel
    - Council Current Events email
    - City Source newsletter
- **Two-Way Communication**
    - Community Workshops
    - Stakeholder Interviews
    - Media relations (media briefings & meetings with the editorial board)
    - Presentations to groups at their meetings
    - Online questionnaire
    - Social media posts to keep stakeholders informed and notified of input opportunities

Implementation is a mutual effort with specific responsibilities outlined in consultant scope of work. What is not included in the scope of work is the responsibility of the City staff.

Section 9. Anticipated Timeline

The stakeholder engagement activities will occur between May 2016 and March 2017.



Notes:

Community workshops are scheduled for October 12, October 26 and November 14, 5:30 to 7:30 p.m. at ARC.

Feb 6 worksession with City Council; Feb 24 Draft Plan materials due in Council packet, 2 readings in March 6 & 20. March 20 public comment on draft plan will be solicited.

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Columbia Wastewater and Stormwater IMP

Attachment J

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Our Columbia Waters
Integrated Management Plan
Wastewater & Stormwater

Technical Memorandum 8
Community Outreach Results

Columbia Wastewater and Stormwater Integrated Management Plan

Columbia, Missouri
November 1, 2017

HDR

Geosyntec consultants
Shockey Consulting Services, llc
TREKK DESIGN GROUP, LLC

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Section 1. Introduction

The City of Columbia, Missouri (City) is working to develop an Integrated Management Plan (IMP) for the City's wastewater and stormwater utilities. The goal of the IMP is to develop an adaptable and affordable long-term plan that addresses the City's wastewater and stormwater management needs and meets Clean Water Act requirements. The IMP will be developed based on guidance presented in US Environmental Protection Agency's (EPA) *Integrated Municipal Stormwater and Wastewater Planning Approach Framework*[1]. According to EPA's framework, municipalities pursue the following principles when conducting integrated planning outreach activities:

- Provide appropriate opportunities that allow for meaningful input during the identification, evaluation, and alternative selection phases of the planning effort,
- Make new information available and provide opportunities for input into the development of proposed modifications of the plan, and
- Allow public involvement to assist in evaluating the opportunities and effectiveness of potential green infrastructure alternatives, if they are relevant to the plan.

HDR Engineering, Inc., Shockey Consulting LLC, and Geosyntec Consultants, Inc., worked with City staff (hereinafter referred to as the "project team") to implement an engagement strategy that described the planning process, provided for continuing input by stakeholders, and ensured that stakeholder concerns received fair consideration. The approach was intended to bring a diverse group of stakeholders together, educate them regarding various options, and gather input in a structured, inclusive, and transparent process.

In the context of EPA's integrated planning framework, community outreach should be an ongoing process that is used inform and refine IMP goals and outcomes over time. Therefore, the City expects that future IMP activities will be reviewed through outreach activities such as public hearings and Columbia City Council meetings. The purpose of this memorandum is to describe the methods used to conduct outreach activities and document the outcomes for the initial phase of the IMP. Community outreach results will be used to assist in identifying and prioritizing IMP goals and the alternatives necessary to meet those goals. Results from the community outreach activities are documented in the sections that follow.

[1] Stoner, N. and C. Giles. 2012. Integrated Municipal Stormwater and Wastewater Planning Approach Framework. June 5, 2012. Washington D.C.

Section 2. Outreach Approach

Early and continuous outreach efforts help bring diverse perspectives and values into decision-making processes. The IMP project team attempted to capture this diversity by soliciting input from a variety of stakeholders throughout the process, with the ultimate goal of identifying strategies that achieve water quality outcomes and public health and safety protections that are important to the community. The project team followed five principles in developing the outreach approach:

- Developing an informed group of stakeholders that understand the benefits and strategies of implementing available wastewater and stormwater management strategies.
- Informing the stakeholders by providing balanced and objective information to assist them in understanding the problems, alternatives, opportunities, and solutions.
- Consulting the stakeholders by obtaining feedback on water quality and infrastructure priorities and desired outcomes.
- Involving the stakeholders by working directly with them throughout the process to ensure that concerns and expectations were consistently understood and considered, ensuring stakeholder groups were included and consulted.
- Building partnerships with other agencies and stakeholders, recognizing the effect this effort has on the community and other sustainable infrastructure initiatives.

Using these five principles, the project team identified key stakeholders and communication methods to obtain relevant feedback that would help guide development of the IMP. A summary of these stakeholders and methods are included in the next sections.

2.1 Identifying Key Stakeholders

In addition to providing information and soliciting feedback from the general public, the project team worked to identify key stakeholders from a balance of interests across the community. These stakeholders included representatives from the Columbia City Council, government agencies, representatives of economically and socially disadvantaged populations, environmental and conservation groups, the business and development community, nonprofit and civic organizations, large impervious surface property owners, and residents who have experienced chronic building backups.

The team reached out to specific organizations within these groups to get a wide variety of input through the process. Specific organizations included:

- Columbia City Council
- Boone County Health Department
- Boone County Regional Sewer District
- Central Missouri Community Action Center
- Central Missouri Opportunity Council
- Churches
- Columbia Audubon Society
- Columbia Chamber of Commerce
- Columbia Housing Authority
- Downtown Columbia Leadership Council
- Downtown Infrastructure Council
- Friends of Rockbridge Memorial State Park
- Hinkson Collaborative Adaptive Management Stakeholders
- Lawn Care Companies
- League of Women Voters of Columbia-Boone County
- Local Developers and Construction Companies
- Local engineers
- Local Industry
- Missouri Department of Natural Resources
- Missouri Department of Conservation
- Missouri River Relief
- MODOT Diversity Council
- MS4 Coordinating Committee
- NAACP
- Neighborhood Associations and Home Owners
- PedNet
- Sierra Club
- University of Missouri

2.2 Communication Methods

Outreach efforts with the general public focused on preparing and providing relevant information to educate the community at large and getting high-level, value-based input from interested stakeholders. One-way and two-way communication methods were used to gain this input. One-way communication activities were intended to provide key information to stakeholders, while two-way communication activities allowed stakeholders to provide input to the project team. Two-way communication activities are summarized in **Section 2.3**. One-way communication activities included the following:

- **Fact Sheets:** A project factsheet was developed to introduce the IMP, share the desired outcomes, and provide opportunities for the public to get involved. The factsheet included the date, time, and location for community workshops and provided detailed information at each of the topics to be presented in the series. The factsheet was distributed via email to stakeholders.

- **Project Website:** A dedicated project website (www.ourcolumbiawaters.com) was created to provide a convenient way for the public to access information at their own pace and schedule. The website included information about upcoming outreach opportunities, provided community workshop results and technical IMP documents, and hosted a community survey.

- **Social Media:** Social media posts were used to keep stakeholders informed and notify the public of opportunities to provide input into the IMP.

- **Media Relations:** Press releases were issued for IMP meetings and media briefings occurred during community workshops.

2.3 Two-Way Communication Activities

Two-way communication activities included briefing members of the Columbia City Council (Council), preparing an online community survey, and conducting a series of community workshops. A total of 162 people participated in the survey and 77 unique participants attended at least one of the four community workshops. A summary of these activities is included below.

Columbia City Council Briefings

In addition to conducting a survey and hosting workshops to obtain input from the general public, the project team met with Council members throughout development of the IMP so that they were informed about the planning process. The project team invited each Council member to meet, both individually and in pairs, and discuss the planning process; these meetings were held early during the Visioning phase of the project to ensure that each person's priorities were captured in the plan and then later to discuss the engineering alternatives, costs, and potential ratepayer impacts associated with addressing those priorities. A draft of the IMP plan was presented to the Council during a work session on August 7, 2017. Upon completion of the planning process, the final IMP will be presented to the Council for their approval and direction in implementing the plan.

Online Community Survey Summary

The survey focused on obtaining input to prioritize community needs and identify local waterbody uses. The survey was hosted on the website and participants who attended the first community workshop were provided a paper version. The online survey was also sent out to a distribution list of over 150 stakeholders. The online survey received input from 133 respondents, while 29 respondents filled out the paper version. The results of both survey forms are summarized below and included in **Attachment A**.

- Sewage overflows into streams, maintenance of the storm and sewer systems, and the protection of natural resources are the top three infrastructure concerns related to the wastewater and stormwater systems.
- Hinkson Creek, the Missouri River, and Gans Creek/Rock Bridge State Park were identified as the three most important waterbodies to protect.
- Over 40% of respondents indicated that they swim in Stephens Lake. Some respondents indicated that they swim in other area waterbodies.
- A majority of survey respondents indicated that they wade, boat, canoe, or fish on area waterbodies. The Missouri River, Stephens Lake, and Gans Creek/Rock Bridge State Park are the top three waterbodies for these uses.
- Almost all (98%) survey respondents hike, walk, bike, camp, hunt, watch wildlife or participate in social events in or near area waterbodies.

Community Workshop #1

The first community workshop was held on October 12, 2016 where input was gathered from 42 stakeholders. The goal of Workshop #1 was to identify the community's highest wastewater and stormwater infrastructure concerns.

Through a series of survey questions and group activities, workshop attendees prioritized the following issues:

- Erosion,
- Flooding,
- Maintaining storm and sewer systems,
- Natural resource protection,
- Planning for growth,
- Sewage backups into buildings,
- Sewage overflows into streams, and
- Stormwater pollution.

Workshop attendees identified maintaining storm and sewer systems, natural resource protection, and planning for growth as the highest infrastructure priorities. These results are similar to the overall survey results which indicated that sewage overflows into streams, maintaining storm and sewer systems, and natural resource protection were most important (**Figure 1**).

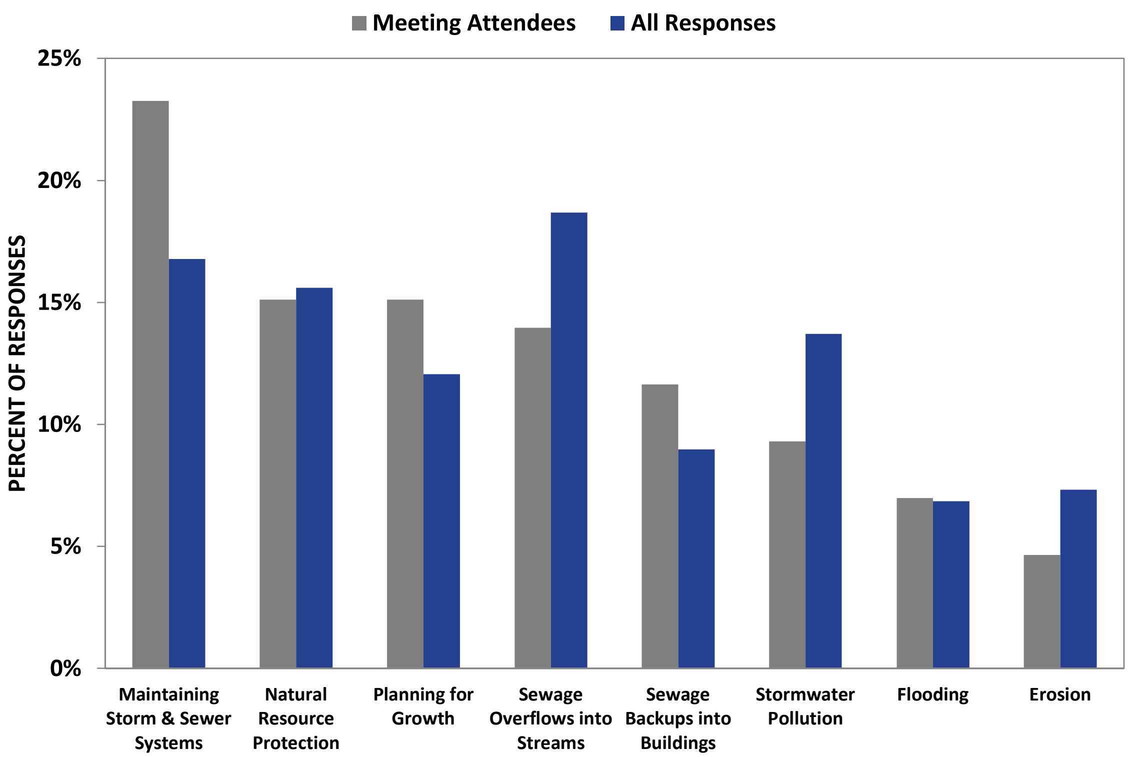

Figure 1. Infrastructure Priorities Identified by Workshop Attendees Compared to the Overall Survey Results.

Community Workshop #2

The second community workshop was held on October 26, 2016 where input was gathered from 40 stakeholders. The goal of Workshop #2 was to identify how the community uses and prioritizes protection of regional waterbodies. Through a series of short presentations and group activities, the workshop attendees provided input on the following questions:

- How do we use our waterbodies?
- What are our water quality and waterbody priorities?

In one exercise, participants provided input on how waterbodies in the area are used. In the second exercise, each workshop participant was given $1.00 and was asked to allocate their money to watersheds they felt were most important to protect. Participants had a choice from among 19 watersheds. Participants could split the money equally, put money only in the watersheds most important to them, or even put their entire dollar in one watershed. The Hinkson Creek watershed, Bonne Femme watershed, and Missouri River/Eagle Bluffs Conservation Area were identified as most important (**Figure 2**).

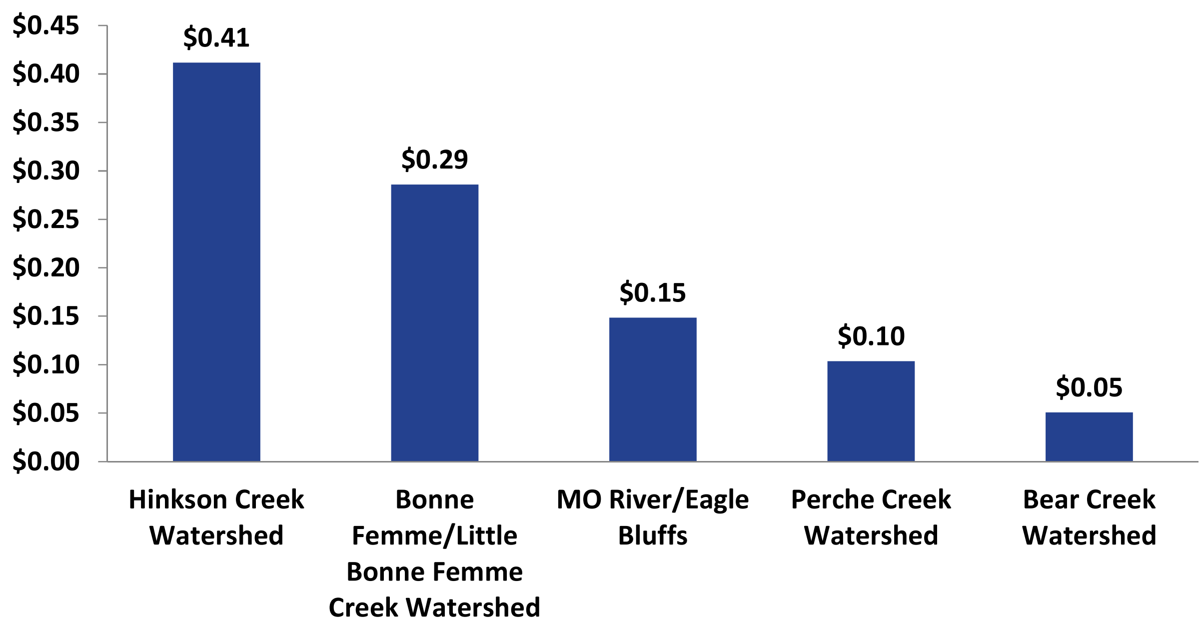

Figure 2. Watershed Prioritization Results. Results were grouped by major watershed or waterbody for presentation purposes. For results of all 19 watersheds and/or waterbodies evaluated, see Attachment B.

Community Workshop #3

The third community workshop was held on November 14, 2016 where input was gathered from 23 stakeholders. The focus of Workshop #3 was discussing the complexities associated with balancing infrastructure improvements, regulatory requirements, and ratepayer affordability. The project team described these issues in detail and explained the importance of identifying decision criteria that could be used to differentiate between and prioritize the various wastewater and stormwater alternatives considered in the IMP.

Building on prior workshops and survey results, potential prioritization criteria and investment strategies were presented in an effort to show participants how the City could evaluate investments using triple bottom line (social, economic, and environmental) factors. Participants provided input into the pros and cons of the criteria and investment strategies. In general, the group identified protecting public health, improving or maintaining property values, improving or maintaining trails and green space, and reducing localized flooding as the most important prioritization criteria (Figure 3). These results are similar to the online survey results, which identified protecting public health, improving or maintaining trails and green space, and reducing localized flooding as most important.

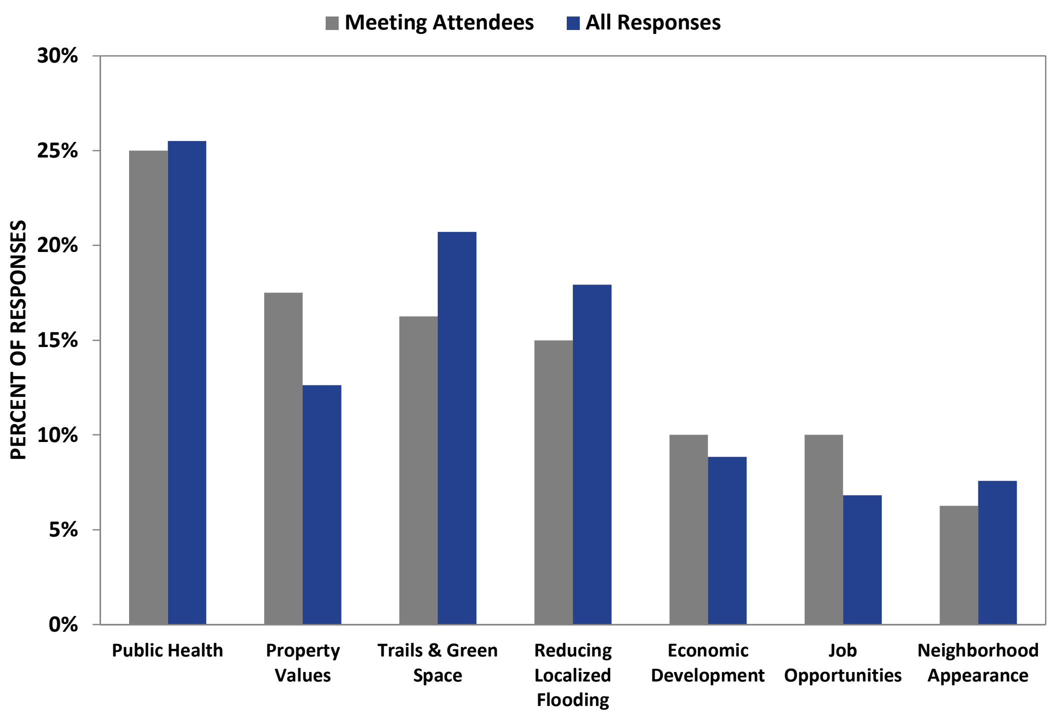

Figure 3. Prioritization Criteria Identified by Workshop Attendees Compared to the Overall Results.

Community Workshop #4

Workshop #4 was held on June 28, 2017 and was attended by more than 20 stakeholders. At the workshop, the project team described how the infrastructure needs, water quality priorities, and prioritization criteria identified in the first three workshops were used to develop preliminary wastewater and stormwater alternatives and investment strategies. Stakeholders then participated in an exercise to help refine the prioritization of those strategies. Results from this exercise are discussed in greater detail in **Section 3**. During the workshop, the team also outlined the multiple criteria decision analysis (MCDA) process that will be used to compare benefits and costs of each alternative. Details regarding the MCDA evaluation are presented in Technical Memorandum 9.

Section 3. Applying Outreach Results to the IMP

Results from the community outreach activities will directly inform development of the IMP by highlighting important infrastructure, environmental, and public health needs; informing development of targeted alternatives to address those needs; and identifying criteria by which potential solutions should be evaluated to identify projects that most directly address the community's objectives for the IMP.

The project team reviewed feedback received over the course of the IMP outreach activities and found that maintaining storm and sewer systems was consistently the highest programmatic and infrastructure-related priority for Columbia stakeholders. However, other issues such as natural resource protection, planning for growth, building backups, sewage overflows into streams, and flooding were also important concerns that should be addressed through the IMP. Although all waterbodies in and around Columbia are important to Columbia residents, Hinkson Creek and its tributaries, Eagle Bluffs Conservation Area, and regional high quality streams (Bonne Femme and Little Bonne Femme Creeks) are generally valued highest.

Based on these results, the project team developed a series of potential wastewater treatment, wastewater collection, and stormwater system alternatives to specifically address the infrastructure needs and waterbody concerns identified by the community. The alternatives are outlined in Technical Memoranda 5, 6, and 7. The alternatives will be evaluated with respect to overall triple bottom line IMP objectives that were identified and prioritized by the community. The triple bottom line objectives and rankings (**Table 1**) were initially developed by the project team based on feedback received in the online survey and first three community workshops, and revised based on community input from the last workshop. Final objectives and weights reflect feedback received from all outreach activities as well as input provided by Council members during individual briefings.

Table 1. Final Community Triple Bottom Line Objectives and Prioritization Weights Used to Evaluate Sewer and Stormwater IMP Alternatives.

Prioritization Scenario	Community IMP Objectives				
	Social Objectives		Economic Objective	Environmental Objectives	
	Improve Public Health and Safety	Improve Quality of Life	Provide Sustainable Services for the Future	Improve Water Quality	Regulatory Compliance
Initial Community Prioritization Results	25%	10%	25%	25%	15%
Final Community Prioritization Results	36%	15%	19%	16%	14%
Final IMP Prioritization Weighting	**30%**	**15%**	**20%**	**20%**	**15%**

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Technical Memorandum 8

Attachments

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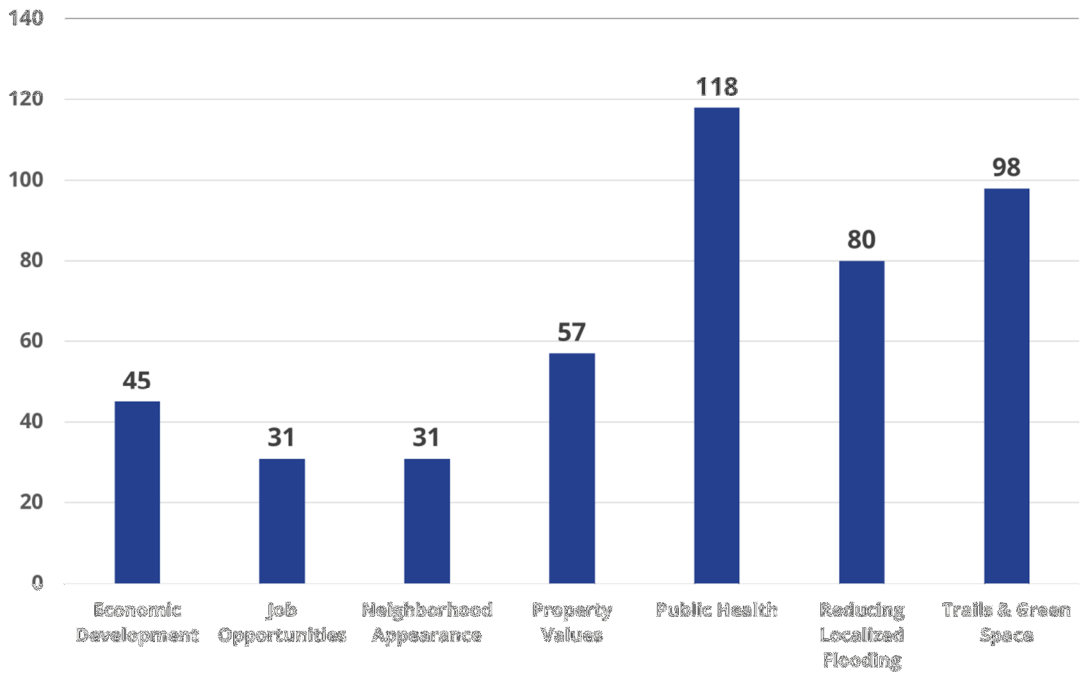
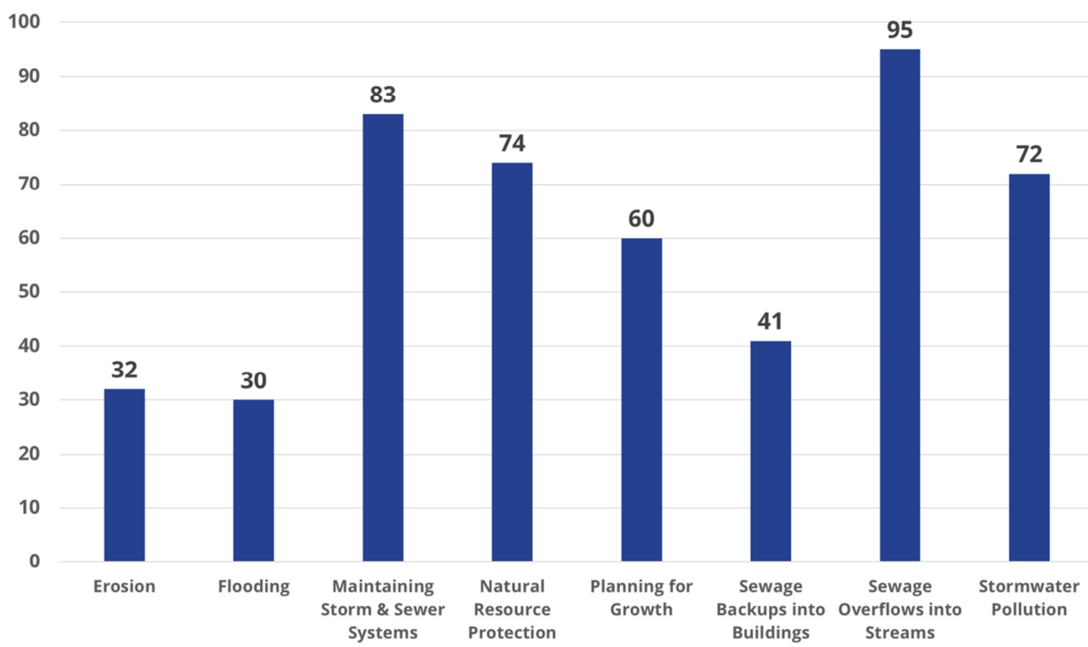
Attachment A. Survey Results

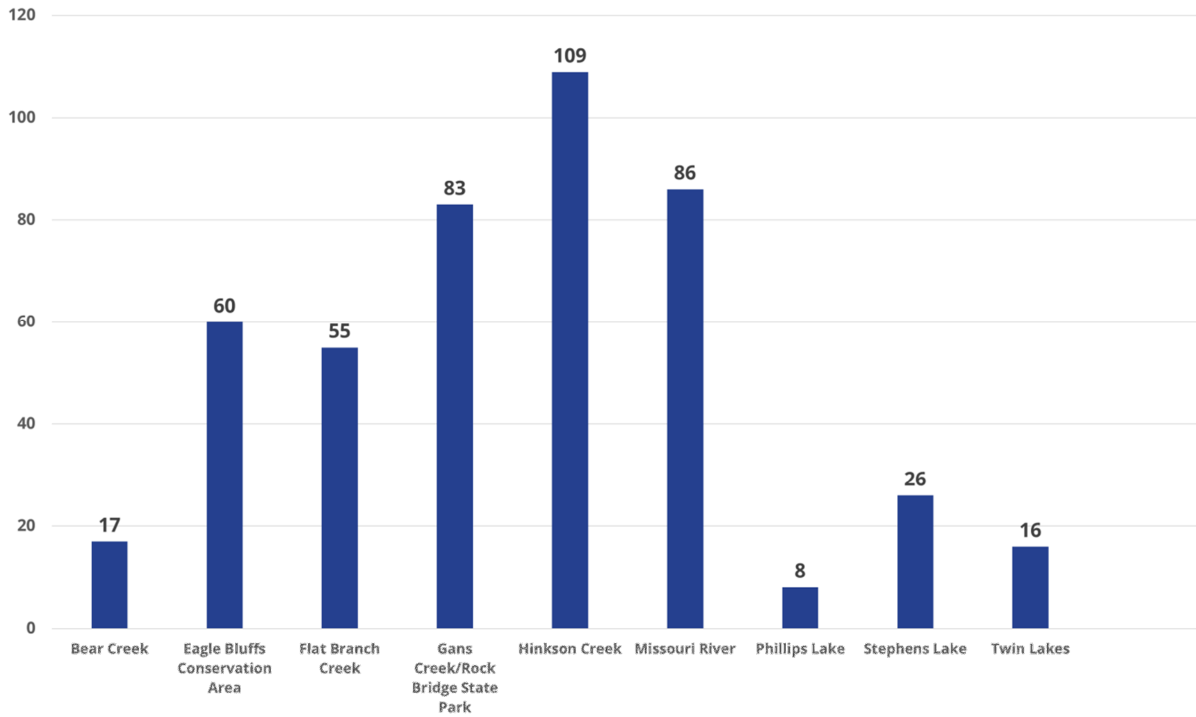
Question 1: As we are making improvements to our stormwater & wastewater systems, there are ways we can efficiently and effectively spend our resources in an effort to achieve multiple community benefits. Which benefits do you feel are most important for your community? Choose THREE of the benefits most important to you.



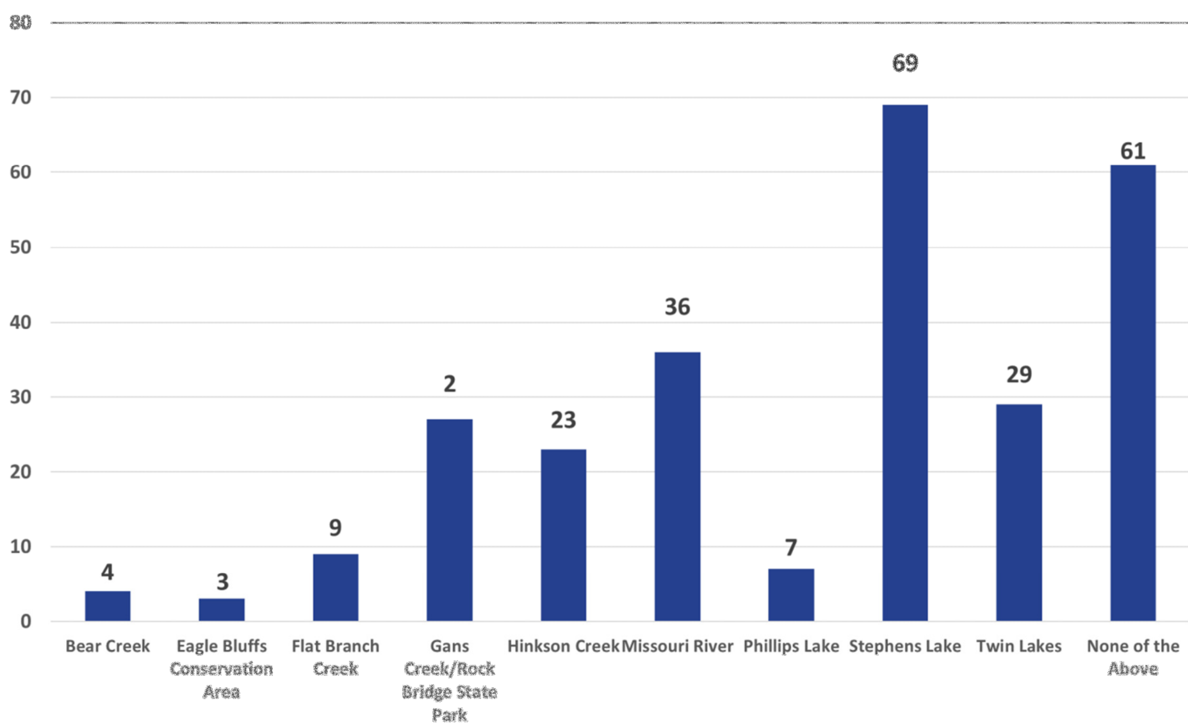
Question 2: Our stormwater and wastewater systems can impact our community in many different ways. What issues are most important to you? Choose THREE of the issues most important to you.



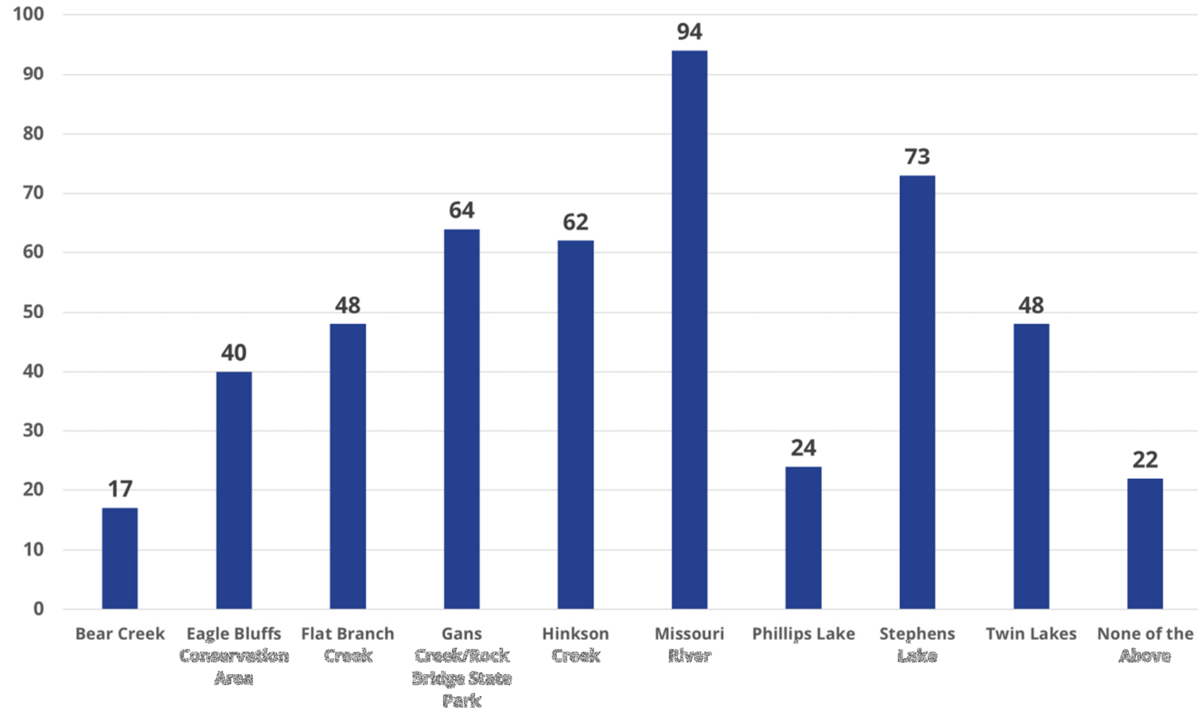
Question 3: Which water bodies do you think are the most important to protect? By checking the boxes below, choose THREE of the water bodies most important to you.



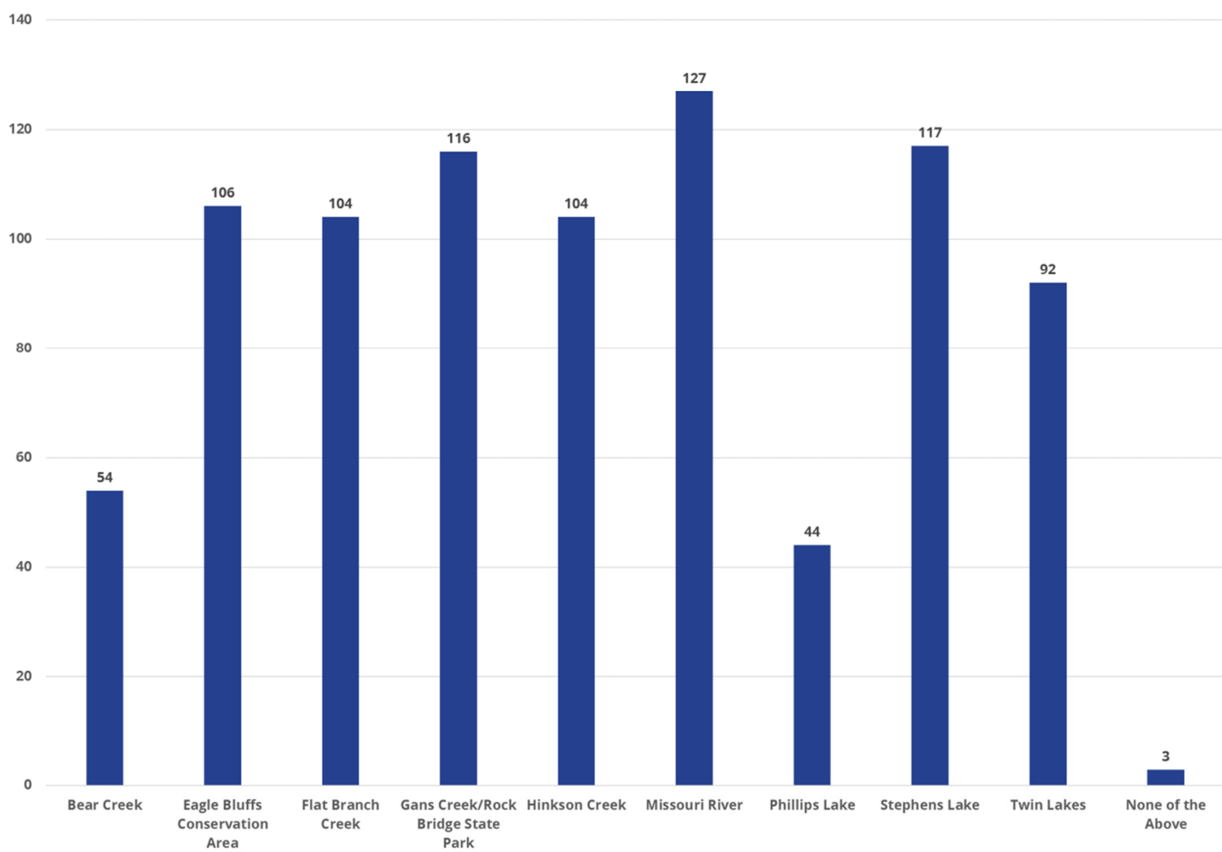
Question 4: Do you or your family members <u>swim</u> in the following water bodies?



Question 5: Do you or your family members wade, boat, canoe or fish on these water bodies?

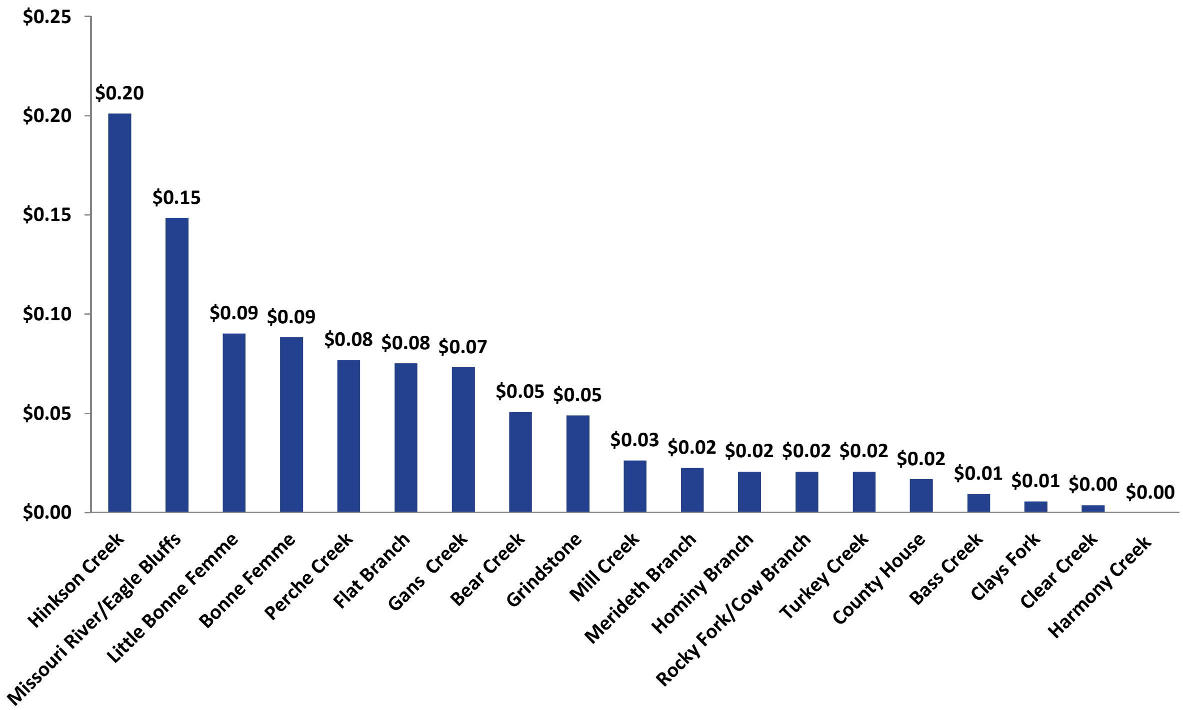


Question 6: Do you or your family members hike, walk, bike, camp, hunt, watch wildlife or participate in social events on the banks of these water bodies?



Attachment B. Watershed Prioritization Results

Question to Workshop Participants: If you could only spend $1 to protect watersheds in and around the City, how would you spend it?



Columbia Wastewater and Stormwater IMP

Attachment K

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Our Columbia Waters
Integrated Management Plan
Wastewater & Stormwater

Technical Memorandum 5 *Wastewater Collection System Alternatives*

Columbia Wastewater and Stormwater Integrated Management Plan

Columbia, Missouri
January 5, 2018

HDR

Geosyntec consultants
Shockey Consulting Services, llc
TREKK DESIGN GROUP, LLC

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Section 1. Introduction and Objectives

The City of Columbia, Missouri (City) is working to develop an Integrated Management Plan (IMP) for the City's Sewer and Storm Water Utilities. The goal of the IMP is to develop an adaptable and affordable long-term plan that addresses the City's wastewater and stormwater management needs and meets Clean Water Act requirements. The IMP will be developed based on guidance presented in US Environmental Protection Agency's (EPA) *Integrated Municipal Stormwater and Wastewater Planning Approach Framework*[1].

Early in the IMP process, the City and their project team worked to evaluate the City's environmental resources and infrastructure assets to better define the existing condition, performance, and needs of its systems. Results from these efforts were documented in the following technical memoranda:

- Technical Memorandum 1 – Surface Water Quality and Biological Conditions
- Technical Memorandum 2 – Wastewater Collection System Assessment
- Technical Memorandum 3 – Wastewater Treatment System Assessment
- Technical Memorandum 4 – Stormwater System Assessment

These needs assessments were useful in guiding initial prioritization of potential wastewater and stormwater improvements. Priorities were further refined during a series of community outreach meetings. Information developed from these activities formed the basis for identifying potential capital and programmatic alternatives that should be evaluated as part of the IMP. Outcomes from these efforts have been documented in the following technical memoranda:

- Technical Memorandum 5 – Wastewater Collection System Alternatives
- Technical Memorandum 6 – Wastewater Treatment System Alternatives
- Technical Memorandum 7 – Stormwater System Alternatives
- Technical Memorandum 8 – Community Outreach Results

The purpose of this memorandum is to describe the assumptions and methods used to develop potential IMP alternatives and corresponding funding requirements for addressing wastewater collection system needs. A number of capital and programmatic needs were identified during the wastewater collection system assessment and documented in Technical Memorandum 2 (TM2). These needs include:

- Develop and implement strategies to support system renewal and maintenance efforts using an asset management approach, including a mechanism to establish sufficient dedicated funding for these efforts.
- Address system capacity limitations and reduce inflow and infiltration (I/I) to reduce building backups and sanitary sewer overflows (SSOs) caused by wet weather flows within the collection system.

[1] Stoner, N. and C. Giles. 2012. Integrated Municipal Stormwater and Wastewater Planning Approach Framework. June 5, 2012. Washington D.C.

- Maintain or improve the City's performance in collection system maintenance to ensure dry weather backups and SSOs due to blockages do not increase despite the challenges presented by aging infrastructure and community growth. Ensure adequate funding is available to achieve these priorities.
- Update the collection system goals to ensure they correspond to the City's short and long term collection system management goals. Achieving these goals should be measured through actionable Key Performance Indicators (KPI's) that support the City in making business decisions, allocating resources, and identifying potential challenges that could negatively impact performance and service levels.

Alternatives to address these needs were developed by HDR Engineering, Inc. (HDR), and TREKK Design Group LLC (TREKK), based on information compiled for TM2, Sewer Utility staff goals, estimated implementation costs, and community priorities. Representatives from HDR and TREKK met with City staff on January 10 and March 8 to review and confirm information and assumptions used to formulate the final alternatives presented in this memorandum.

Given the uncertainties and data gaps identified during the existing system evaluation, the alternatives outlined in this memorandum are only intended to serve as planning level estimates. These alternatives and associated costs should be refined as additional information is developed during future phases of the IMP. Findings from the collection system alternatives analysis are documented in the sections that follow.

Section 2. Level of Service Goals

The City currently has some performance criteria and production goals that are used to guide sewer operations. However, more formal level of service (LOS) goals will likely be needed in the future to adequately measure wastewater collection system performance. Through the IMP process, the City has begun the process of developing long term goals and the programmatic strategies to achieve them and track performance in this area over the 20-year IMP planning period.

Goals are typically tracked through a series of KPIs used to evaluate a utility's success in meeting strategic goals, quantify the benefits of continuous improvement initiatives, and to measure performance in managing gravity sewer infrastructure. When identifying KPIs to track, particular emphasis should be placed on developing "actionable" KPIs that support the City in making business decisions, allocating resources, and identifying potential challenges that could negatively impact performance and service levels if they are not addressed. It is typically most effective for a utility to track a relatively small number of actionable KPIs with meaningful goals that support decision making, rather than a larger number of statistical KPIs that do not inform management decisions. In recent years, the City has made significant progress towards developing long term strategies and is already collecting the key data needed to monitor collection system program progress.

However, formal goals specific to the collection system cannot yet be fully developed until the IMP process is completed and the different IMP components (wastewater treatment, stormwater system, and wastewater collection system) are prioritized to meet the community objectives. There are also existing data and information gaps that must be filled in order to develop formal goals in some key areas. For example, the City needs to develop an accurate hydraulic model to understand the costs and benefits of establishing a specific collection system design storm prior to defining the City's LOS goal for wet weather conveyance.

Therefore, defining final system performance goals on a numerical basis will not be completed at this time. These goals will instead be discussed in the context of the City's goals developed through the IMP visioning process and identified in TM2.

During the January 10 workshop, HDR and the City discussed potential goals and KPIs related to dry weather system performance, wet weather system performance, and system renewal[2]. The City's current performance, informal staff goals, and documented Sewer Utility goals were reviewed in the context of these three performance categories. Examples of goals and KPIs tracked by other regional utilities with similar priorities were also reviewed and discussed. Potential dry weather, wet weather, and system renewal goals and KPIs that the City may want to consider evaluating for use in their program going forward are described in the sections that follow.

[2] Dry and wet weather programs are interrelated and performance in one of these areas directly impacts the other. System renewal measures can support both the dry and wet weather system performance by reducing failures and public sector I/I.

2.1 Dry Weather System Performance Goals

The primary methods used to measure LOS in dry weather performance are dry weather backups and SSOs. These are typically measured in the number of these events annually per 100 miles of pipe, with a particular emphasis on the events the City has the greatest direct control over; those caused by blockages or structural failures on publicly owned infrastructure.

The City's performance in this area in recent years is in line with industry standards for effective utility management. The City has maintained an average of less than 2 events per year per 100 miles every year since 2010. Recommended KPIs to track and measure progress in dry weather system performance are listed below, along with a summary describing the KPI.

LOS Measurement - Dry Weather Backups and SSOs per 100 miles of pipe:

- Number of Dry Weather Backups and SSOs per 100 miles of pipe.
- Cleaning Goal Compliance – A measure of progress towards meeting the City's proactive cleaning strategy. This is measured by determining what percentage of pipes were able to be cleaned on or before their scheduled cleaning date based on the City's proactive maintenance policy (currently 5 years for accessible pipes).
    - Cleaning Productivity – A measure of the output of the cleaning program. This is measured by the miles of pipe cleaned in comparison to the mileage that needs to be cleaned each year to meet the City's proactive maintenance policy.
    - Long Term Cleaning Workload Tracking – A measure of the long term mileage needed to be cleaned in order to meet goals. Tracked in order to identify future changes to workload so the superindent can plan for future peaks and valleys in cleaning work needed.
    - Short Term Cleaning Workload Tracking – A measure of pipes that will come due in the near term (usually 3, 6 , or 12 month increments). Tracked in order to identify near term changes in workload so management can plan accordingly (i.e. focus more resources on cleaning than Closed Circuit Television (CCTV) in a particular month if needed to meet goals).

2.2 Wet Weather System Performance Goals

Wet weather LOS is often measured by the number of wet weather backups and SSOs per year. System performance during wet weather is measured by SSO rates, typically measured in terms of SSOs per 100 miles of pipe. During times of excessive wet weather, system flows can reach levels that cannot be feasibly conveyed. Therefore, it is preferable to also measure wet weather LOS relative to the ability to convey flows produced during a specific design storm event. Some regional utilities have established design LOS of a 10-year or 5-year storm event, although others use more or less frequent events such as the 2-year or 50-year storms depending on their specific performance and system goals.

The City's performance in this area in recent years, along with a description of existing data gaps in flow monitoring and hydraulic modeling, is documented in TM2 and discussed in **Section 3**. The City intends to establish LOS goals for the collection system but first needs a tool to evaluate the costs of improvements to achieve each LOS and prioritize these relative to other system needs. In order to do so, the City needs to update their existing hydraulic model. After this has been completed, the City will be able to define formal wet weather LOS goals.

Examples of KPIs typically used by wastewater utilities to measure progress in wet weather system performance are listed below. Specific and appropriate KPIs will be selected during subsequent phases of the IMP when more data are available.

- Total Wet Weather Backups and SSOs per 100 miles of pipe
- Wet Weather Backups and SSOs per 100 miles of pipe for events below collection system design storm event
- System Performance Understanding – A measurement of knowledge gaps indicating what percentage of areas have accurate flow and capacity data available for decision makers. Note that this may not be necessary for all areas wtihin the system.
- Percentage of System Able to Convey Design Storm – A measurement of the percentage of the system (measure both by line segments and length) able to convey the design storm.
- I/I Reduction Achieved – A quantificiation of the I/I reduced within a specfic basin or sub-basin by City's efforts.
- Cost Effectiveness of I/I Reduction – A measurement of the cost of I/I reduction, typically tracked at the project or sub-basin level.

2.3 System Renewal Goals

The primary methods used to measure system renewal goals are typically based on the quantity of renewal work completed, and the condition of the system based on CCTV assessment and manhole inspections. Renewal needs vary based on system age, material, design standards, and level of risk acceptable by the utility. Details of the City's current condition assessment and system renewal programs are provided in TM2 and **Section 3**.

Recommended KPIs to track to measure progress in wet weather system performance are listed below, along with a summary describing the KPI.

- System Renewal Output – Tracked both by percentage of system and mileage renewed.
  - Contracted System Renewal Output – A measure of the amount of contracted renewal work completed each year (currently mainly consisting of CIPP lining of pipes and contracted manhole rehabilitation).
  - In-House System Renewal Output – A measure of the amount of renewal work completed by utility staff per year.
- CCTV Goal Status – A measure of the amount of CCTV assessment completed relative to the City's goals.
  - CCTV Output – A measure of the output of the CCTV program. This is measured by the miles of pipe televised in comparison to the City's goal.
  - Percentage Inspected – A measure of the amount of the system televised relative to the City's programmatic needs. This KPI can be tracked on a systemwide basis, or by pipe material, age, or basin. Note that although the City must inspect sewer and stormwater pipes associated with new construction before accepting the work, many of these pipes do not necessarily need to be reinspected frequently thereafter. This would all the City to focus CCTV resources on the areas where they provide the greatest value.
- Manhole Inspection Goal Status – A measure of the City's compliance with manhole inspection goals. When accessed for cleaning, all manholes currently receive a brief, high-level inspection intended to identify significant strucutral issues or I/I sources. Detailed manhole inspections have primiarly been focused in high I/I areas.

Section 3. Funding Scenario Development

As mentioned previously, uncertainties and data gaps that currently exist in the collection system preclude the development of specific project recommendations or alternatives at this time. Instead, planning level estimates were identified to characterize the expected additional level of investment required to address system needs, anticipated regulatory drivers, and City goals over the next 20 years (the IMP planning period). It is important to note that these estimates represent the investments and activities needed **in addition to** the resources the Sewer Utility currently manages or are otherwise already dedicated. Three potential funding level scenarios were used to guide the analysis. They are broadly defined as follows:

- **Level 1 Funding (Level 1) –** Funding needed to **provide the minimum** LOS that meets both community-wide expectations and **existing** regulatory requirements over the 20-year IMP planning period.
- **Level 2 Funding (Level 2) –** Funding needed to **exceed the minimum** LOSthat meets community-wide expectations and **more proactively** meets existing regulatory requirements over the 20-year IMP planning period.
- **Level 3 Funding (Level 3) –** Funding needed to **address all** forecasted infrastructure needs and proactively meet **both** existing and forecasted regulatory requirements over the 20-year IMP planning period.

The estimates include potential additional capital costs, operation and maintenance costs, and costs associated with necessary planning or data collection activities needed over the 20-year IMP planning period. The resulting spending differences between each funding level presented above are the product of assumptions related to the total project implementation cost, project scheduling, and the timing of known regulatory drivers. Funding level estimates were developed for 10 major sanitary sewer collection system project categories focused on improving infrastructure, customer service, and water quality. These categories are as follows:

- Wet Weather Program Planning and Management
- Asset Management Support
- System Renewal and Public I/I Reduction
- System Capacity Enhancement and Private I/I Reduction
- Building Backup Alleviation
- Private Common Collector Elimination
- System Expansion
- Cleaning Program
- Pump Station Repair and Rehabilitaiton (R/R)
- Annual Sewer Improvements

These program areas and funding assumptions were reviewed and refined during workshops with City staff. Methodologies used to develop funding level estimates for each of these project categories are described in the sections that follow. Detailed costs forecasts for each funding level are presented in **Attachment A**. Note that costs were allocated to specific years for planning purposes only and help facilitate comparisons between the alternative levels. Actual annual costs and timing of projects will be addressed in the final IMP.

3.1 Wet Weather Program Planning and Management

One of the City's primary goals identified during IMP visioning was to address system capacity limitations and reduce building backups and SSOs caused by wet weather flows in the collection system. Addressing the performance of the collection system during major wet weather events has been a primary area of focus for the City in recent years. The City has continually worked to reduce overflows and backups through a combination of I/I reduction efforts, operational changes, and capacity improvement projects.

The City would like to establish a LOS goal for the collection system and develop a plan to meet that goal (e.g., convey a specific design storm event without backups or SSOs). In order to determine the preferred LOS goal, the City first needs to be able to evaluate the costs of improvements to achieve each LOS. Once these needs have been identified, the resources needed to meet different wet weather LOS and corresponding benefits can be evaluated along with other capital expenditures. This will allow the City to prioritize these needs relative to other needed improvements.

The City's most recent hydraulic model is based on flow monitoring data that is over 15 years old and had significant data gaps that compromises model accuracy. These data are outdated and the model is not sufficiently accurate to develop the City's long term capacity improvement needs with a high degree of confidence. The first step in the planning process is to obtain updated system wide flow monitoring data to use as the basis for calibrating and refining an accurate hydraulic model of the collection system. This model will then be used to identify funding needs and ultimately develop a long term improvement plan to address the capacity issues present within the system. Note that the improvements will likely be a combination of I/I reduction and collection system capacity improvements.

Estimated costs for flow monitoring and hydraulic model refinement were used as the basis for estimating the funding needs for the first steps in developing the wet weather planning and management program. Additional resources will be needed to manage future program activities. These will likely include planning to address existing capacity restrictions and future growth, along with the management of I/I reduction efforts. Assumptions used to develop the funding scenarios are as follows:

- **Level 1 – Hydraulic Model Refinement and Lower Level of Program Management Support**
    - $600,000 total for flow monitoring and hydraulic model refinement early in the planning period.
    - On average, $100,000 annually for program management support over the 20-year planning period.
    - The addition of two new engineering staff members to help manage and execute the program and one new staff truck to be replaced every 10 years.

- **Level 2 – Hydraulic Model Refinement with Medium Level of Program Management Support**
  - $600,000 total for flow monitoring and hydraulic model refinement early in the planning period.
  - On average, $200,000 annually for program management support over the 20-year planning period.
  - The addition of two new engineering staff members to help manage and execute the program and one new staff truck to be replaced every 10 years.
- **Level 3 – Hydraulic Model Refinement with Higher Level of Program Management Support**
  - $600,000 total for flow monitoring and hydraulic model refinement early in the planning period.
  - On average, $300,000 annually for program management support over the 20-year planning period.
  - The addition of four new engineering staff members to help manage and execute the program and two new staff trucks to be replaced every 10 years.

3.2 Asset Management Support

As the City transitions to a more asset management based approach for collection system management activities, they will be able to forecast maintenance, condition assessment, and renewal investment needs with a higher level of confidence, justify appropriate investment levels, focus limited resources, and facilitate knowledge transfer within the organization. Development and implementation of the asset management program and corresponding strategies will require additional internal and external resources. For initial planning purposes, the funding scenarios assume that external consultants will be retained to assist with asset management support. As the program develops over time, these estimates can be refined to incorporate the appropriate mix of internal and external resources. Assumptions used to develop funding scenarios for asset management support are as follows:

- **Level 1 – Low Level Investment in Asset Management**
  - On average, $75,000 per year over the 20-year planning period.
- **Level 2 – Medium Level Investment in Asset Management**
  - On average, $150,000 per year over the 20-year planning period.
- **Level 3 – High Level Investment in Asset Management**
  - On average, $250,000 per year over the 20-year planning period.

3.3 System Renewal & Public I/I Reduction

The City owns and operates over 715 miles of gravity sewer lines and force mains. The estimated replacement costs for this infrastructure is over $700 million. If not addressed, this existing infrastructure will age, deteriorate, and increase the occurrence and frequency of overflows and backups in the system. Proactive condition assessment and renewal of this infrastructure would allow the City to address aging infrastructure through cost-effective, trenchless rehabilitation techniques that minimize disruption to the public. These renewal activities also address a portion of the infiltration entering the system from public sources, which may reduce backups and SSOs. In addition, these improvements may mitigate potential exfiltration from the sewer system through broken pipes that may adversely affect water quality. If the City is unable to proactively address these system renewal needs, expensive emergency repairs that are disruptive to the community will also increase. In addition, increased funding would allow the City to more aggressively eliminate significant public inflow from sources such as curb inlets, leaky manhole covers, and currently unidentified direct or indirect stormwater connections.

The City's current condition assessment and system renewal program for pipes and manholes is detailed in TM2. The City is currently CIPP lining approximately 30,000 feet or 5.7 miles of pipe each year ($2.7 million annually), as well as completing point repairs. This current system renewal rate equates to approximately 0.8% of the system renewed on an annual basis. Funding for this system renewal work was provided through the 2013 bond issue that established funding for a five year period. This funding is primarily focused on rehabilitation of public infrastructure in areas that experience high I/I. This annual budget of $2.7 million is available through 2019, at which point a new funding source will need to be secured. To sustain the LOS expected by the public, a consistent long term funding source for infrastructure renewal is needed.

City staff has identified a backlog of more than 31 miles of trenchless rehabilitation and more than 150 pipe point repairs to address I/I or structural deficiencies. This represents an existing backlog of approximately $9 million in necessary, near-term system renewal work on pipes alone. However, the unidentified system renewal needs that will be discovered over the IMP planning period through future condition assessment efforts and those that will arise as the infrastructure ages are far greater.

HDR developed an initial estimate of future system renewal needs based on pipe and manhole ages and materials within the City's system, and found that approximately 105 miles of pipe and 3,240 manholes. Costs to address these needs were developed by HDR based on experience with other similar regional utilities. The costs were reviewed with City staff, and refined based on the City's experience with local infrastructure condition and construction methods. This resulted in an estimate of approximately $74 million in infrastructure renewal needs over the IMP planning period, including the existing backlog.

Funding estimates were established based on addressing these system renewal needs over different time periods. If the City can dedicate more resources to system renewal, it is anticipated that this will benefit the system in multiple ways and help the City achieve their LOS goals more quickly. This proactive system renewal work will reduce health, safety, and water quality issues associated with structurally deficient pipes and blockages, and will have the added benefit of helping the City reduce I/I in publicly owned infrastructure. Collectively, these improvements will reduce the number and magnitude of emergency repairs, alleviate wet weather capacity issues at certain locations within the collection system, and reduce exfiltration which will improve water quality and help to address stream impairments throughout the City.

Assumptions used to develop funding scenarios for system renewal are listed below. Note that while the City's existing staffing level is anticipated to be adequate to execute system renewal work at current funding levels, it is anticipated that the City will need additional resources to execute greater volumes of renewal work.

- **Level 1 – Maintain Current Funding Level for System Renewal**
  - Fund projects currently identified in the CIP
  - Maintain $2.7 million annual funding for system renewal. This level of funding would address projected renewal needs within 27 years.
- **Level 2 – Increase Funding Level for System Renewal to Address Estimated Needs Within 20 Years**
  - Fund projects currently identified in the CIP.
  - Increase system renewal funding to $3.7 milion annually.
  - Add two new CCTV staff, two new repair crew staff, one inspector and two new staff trucks to be replaced every 10 years.
  - Add 1 new CCTV Truck to be replaced every 10 years.
- **Level 3 – Increase Funding Level for System Renewal to Address Estimated Needs Within 15 Years**
  - Fund projects currently identified in the CIP.
  - Increase system renewal funding to $4.9 milion annually.
  - Add two new CCTV staff, two new repair crew staff, one inspector, and two new staff trucks to be replaced every 10 years.
  - Add 1 new CCTV Truck to be replaced every 10 years.

3.4 System Capacity Enhancement and Private I/I Reduction

The scope of the program and level of funding needed for system capacity enhancements will ultimately be determined based on the wet weather program management and planning activities discussed above. Capital improvements needed to meet the City's desired level of wet weather service will likely include a combination of capacity improvement projects and I/I reduction efforts.

Public I/I source mitigation is captured under asset renewal projections. Therefore, private I/I control is the primary focus under this program. The cost-effectiveness of private I/I control is highly dependent upon the source and location. For example, inflow reduction from downspout and sump pump disconnections are usually very cost-effective, while lateral replacements and foundation drain disconnections may be more costly than beneficial. The City should evaluate private I/I costs compared to system capacity improvements to determine the most cost-effective strategy to address wet weather challenges. In addition, the City should reevaluate the implementation barriers that limit effectiveness of their current private I/I program.

System capacity enhancement and private I/I reduction needs will be further refined after hydraulic model development and wet weather planning. The assumptions used to develop system capacity enhancement funding levels are as follows:

- **Level 1 – Average of $2 Million Annually for System Capacity Enhancement Program over the 20-Year Planning Period**
  - Fund projects currently identified in the CIP.

- Assume average funding of $2 million annually for capital projects to enhance system capacity or reduce private I/I.
- Additional engineering staff to assist with program execution (these staff are identified in Section 3.1 Wet Weather Program Planning and Management)

- **Level 2 – Average of $4 Million Annually for System Capacity Enhancement Program over the 20-Year Planning Period**
    - Fund projects currently identified in the CIP.
    - Assume average funding of $4 million annually for capital projects to enhance system capacity or reduce private I/I.
    - Additional engineering staff to assist with program execution (these staff are identified in Section 3.1 Wet Weather Program Planning and Management)
- **Level 3 – Average of $6 Million Annually for System Capacity Enhancement Program over the 20-Year Planning Period**
    - Fund projects currently identified in the CIP.
    - Assume average funding of $6 million annually for capital projects to enhance system capacity or reduce private I/I.
    - Additional engineering staff to assist with program execution (these staff are identified in Section 3.1 Wet Weather Program Planning and Management)

3.5 Building Backup Alleviation

There are a number of buildings within the City that experience repeated wet weather backups. These are typically homes or areas of older construction. Backups may be due to poor plumbing practices and/or condition, building floor elevations that were constructed too low relative to the sanitary sewer elevation, inadequate capacity in the sewer system, and private I/I sources connected to the service lateral, or other unknown issues related to individual building plumbing. Many building backups cannot be cost effectively addressed through capacity improvements to the public sewer system.

Funding estimates were established based on potential options to alleviate the backups. Level 1 is based on the lowest cost alternative, which would involve installing backflow prevention valves and other plumbing improvements on individual properties[3]. Level 2 assumes installation of low pressure sewer systems (LPS) and some limited buyouts of affected properties by the City. Level 3 assumes that all properties would be purchased by the City. It is important to note that any program developed to address building backups would have to meet applicable legal requirements for using ratepayer money to address issues on private property. Review of these legal requirements was outside the scope of the IMP.

Assumptions used to develop funding scenarios for building backup projects are as follows:

- **Level 1 – Address Building Backups Through Plumbing Improvements**
    - $500,000 allocated for backflow prevention valves and other plumbing improvements.

[3] During the course of IMP development, the Columbia City Council approved (July 3, 2017) a cost-reimbursement program to address building backups through plumbing improvements. The approved is equivalent to the IMP Level 1 recommendation.

- **Level 2 – Address Building Backups Through LPS Systems and Limited Property Purchaes.**
  - Low pressure sewer system (LPS) installation for impacted properties and limited property buyouts for a total of $5 million over the 20-year planning period.
- **Level 3 – Address Building Backups Through Extensive Property Purchases**
  - Buyout or LPS system installation for impacted properties and limited property buyouts for a total of $40 million over the 20-year planning period.

3.6 Private Common Collector Elimination (PCCE) Projects

Private common collectors (PCC) are privately-owned collection systems that serve multiple homes or businesses. PCCs typically consist of small diameter pipes that have generally not been maintained by the property owners since they were installed. Locating PCCs is also challenging, as they are not on public property and limited mapping is available.

As these are privately owned collection systems, the City does not typically have access to maintain or repair these lines. These aging PCCs are subject to blockage or failure and pose a significant public health and water quality risk; failing PCCs cause building backups, are a significant source of exfiltration that expose the public to raw sewage, and exacerbate I/I issues that ultimately contribute to overflows to local water bodies, .

The City has a dedicated program focused on eliminating these PCCs and replacing them with publicly owned sanitary sewers. This program helps to reduce building backups, improve water quality, and renew aging infrastructure. The City has developed planning level cost estimates for the elimination of known PCCs; these estimated costs were used to help develop projected costs for this program.

Assumptions used to develop PCCE funding levels included in this evaluation are as follows:

- **Level 1 – Address One-Third of Known PCCs During IMP Planning Period**
  - Fund projects currently identified in the CIP.
  - Fund 1/3 ($3.2 million) of known remaining projects.
- **Level 2 - Address Two-Thirds of Remaining Known PCCs During IMP Planning Period**
  - Fund projects currently identified in the CIP.
  - Fund 2/3 ($6.4 million) of known remaining projects.
- **Level 3 – Address More than Two-Thirds of Known PCCs During IMP Planning Period**
  - Fund projects currently identified in the CIP.
  - Assumes additional $9.5 million for known and unknown remaining projects.

3.7 System Expansion

This project category includes funding for gravity conveyance and pump station projects necessary to expand the system for new growth areas or to increase existing system capacity to accommodate the increased wastewater flows generated by growth in the City. Increased capacity may also be needed to accommodate regionalization activities that would reduce the number of small wastewater treatment plants (WWTPs) and improve stream water quality in the area. As discussed in Technical Memorandum 3, more than 100 small WWTPs have been eliminated since construction of the Columbia Regional Wastewater Treatment Plant (CRWWTP) and approximately 11 more are currently joining either the CRWWTP or Boone County Regional Sewer District systems. System capacity should be sufficiently maintained to continue supporting these water quality improvement projects.

As noted in TM2, in recent years Columbia has been the fastest growing city in the state of Missouri. Community growth rates and the locations of new growth are driven by many factors that cannot always be readily predicted by the Sewer Utility. Additionally, the prioritization of system expansion projects relative to other system needs can be driven by community leadership priorities that are outside the control of the Utility. It is important that adequate funding is available to meet the community's priorities in this area, ensure the City can sustain their desired LOS, and comply with regulatory requirements as growth increases flows to the existing system.

Historically, the level of funding the City has dedicated to these projects has varied based on growth rates, system expansion locations, and community priorities. Past projects and those currently in the CIP were used as the initial basis for estimating future system expansion needs. An annual average funding level was determined for each IMP funding scenario in order to ensure the City has sufficient funding to meet community priorities.

Assumptions used to develop funding scenarios for system expansion projects are as follows:

- **Level 1 – $2 Million in Funding Per Year for System Expansion Projects**
    - Fund projects currently identified in the CIP
    - Continue funding at an average of $2 million per year
- **Level 2 – $3 Million in Funding Per Year for System Expansion Projects**
    - Fund projects currently identified in the CIP
    - Continue funding at an average of $3 million per year
- **Level 3 - $4 Million in Funding Per Year for System Expansion Projects**
    - Fund projects currently identified in the CIP
    - Continue funding at an average of $4 million per year

3.8 Cleaning Program

An evaluation of the City's cleaning program was presented in the TM2. The City's maintenance program has showed a strong trend of continuous improvement over the past several decades. The City has worked to reduce the rate of dry weather backups and overflows, and the results are in line with industry standards for an effective maintenance program. However, the Utility is facing challenges that are anticipated to make it harder to continue to meet proactive cleaning goals. These challenges include:

- Columbia is experiencing continued growth of the collection system maintained by the Utility. This growth increases cleaning demands.

- In recent years, the City has increased the mileage of CCTV inspections in order to proactively assess the condition of the collection system and identify and mitigate structural issues and I/I sources. This increases the amount of reactive cleaning needed to support the CCTV crews, and decreases the resources available for proactive cleaning.
- The cleaning trucks have recently moved to a new dispatch facility at the CRWWTP, which has increased the driving time for the cleaning crews to much of the City.

In order to meet these future challenges, optimize the use of resources, and to continue the trend of improved customer service, the City should build on these past successes and move towards implementing an asset management approach for scheduling and executing cleaning of the system. The program would focus on cleaning the right pipes at the right time, e.g., cleaning dirty pipes more often while cleaning relatively clean pipes less often. This would help the City to address the challenges facing the cleaning program and continue the trend of relatively low amounts of dry weather overflows and backups, enabling the City to maintain or exceed LOS goals.

During the alternatives analysis workshop, future cleaning needs and potential optimized cleaning schedules were reviewed. Cleaning resource needs were evaluated for each scenario in the context of anticipated future growth. Although the final scope of the optimized cleaning program has not yet been fully defined, it was determined that for all reasonable scenarios the addition of a 4^{th} cleaning truck and crew will be needed in order to maintain the City's current LOS.

Therefore, Level 1 and Level 2 funding scenarios assume the addition of the 4^{th} cleaning truck and crew, and that an asset management approach to scheduling and executing the cleaning program will be implemented. The Level 3 funding scenario assumes that a 5^{th} cleaning truck will be added. Note that these cleaning resources will also be used to support the sanitary and storm sewer CCTV inspection programs.

- **Level 1 – Add a 4^{th} Cleaning Truck and Implement Asset Management Approach to Cleaning Program**
  - Assume one new cleaning truck (replaced every 10 years) and two new cleaning staff.
- **Level 2 – Add a 4^{th} Cleaning Truck and Implement Asset Management Approach to Cleaning Program**
  - Same as Level 1.
- **Level 3 – Add a 4^{th} and 5th Cleaning Truck and Implement Asset Management Approach to Cleaning Program**
  - Assume two new cleaning trucks (replaced every 10 years) and two new cleaning staffs (4 people total). The additional trucks would also support the sanitary and storm sewer CCTV inspection programs.

3.9 Pump Station Repair and Rehabilitation (R/R)

This project included funding for pump station R/R improvement projects. As pump stations age, mechanical, electrical, process, and structural repairs are required. This can involve both specific equipment replacement, improvements required for code compliance, and complete rehabilitation of aging facilities. Note that this funding is not intended to cover normal operation and maintenance (O&M) needs.

Known R/R projects and general pump station facility needs were reviewed with the City during the workshops. The City's pump stations are in generally good condition and there were no known current major project needs identified by the City. However, pump station mechanical and electrical equipment, as well as the structures themselves, have a finite useful life and R/R projects will be needed within the IMP planning period to keep these stations operating at the level needed to meet the City's desired LOS.

Long-term funding R/R needs were estimated for the three largest pump stations (Clear Creek, Little Bonne Femme, and Cow Branch pump stations) based on a model that HDR previously developed. This model takes into account the size of the pump station and useful life of equipment and structures in order to provide planning level estimates of future R/R needs. For the Level 1 funding scenario, only funding for major R/R expenses at the three largest pump stations was included. For Level 2 and Level 3, additional funding was allocated for unidentified R/R needs at the smaller pump stations.

Assumptions used to develop funding scenarios for pump station R/R projects are as follows:

- **Level 1 – Allocate Pump Station R/R Funding for Major Pump Stations**
  - Fund improvements within planning period to the three largest pump stations based on estimated needs and physical life of equipment and facility.
  - R/R for small pump stations are assumed to be included in normal O&M expenditures.
- **Level 2 – Allocate Pump Station R/R Funding for Both Major and Minor Pump Stations**
  - Fund improvements within planning period to the three largest pump stations based on estimated needs and physical life of equipment and facility.
  - Assume $2 million for unidentified R/R needs at smaller pump stations.
- **Level 3 - Allocate Pump Station R/R Funding for Both Major and Minor Pump Stations**
  - Same as Level 2.

3.10 Annual Sewer Improvements

This project includes funding to address unanticipated sewer improvements and repairs that may be needed in any given year. The Utility's budget for these improvements has varied over time and has averaged approximately $600,000 per year for the last five years. According to City staff, this amount has been sufficient to address needs that are identified. Conservatively, all funding scenarios include $1 million per year for this category.

Section 4. Summary

HDR and TREKK worked with the City to review existing collection system goals and develop alternatives to address system and program needs identified in TM2. Specific needs included supporting renewal and maintenance efforts using an asset management approach, addressing capacity limitations to reduce backups and SSOs, and improving maintenance performance to reduce the potential for dry weather backups and SSOs as existing infrastructure ages.

The City currently has some performance criteria and production goals that are used to guide sewer operations. Through the IMP process, the City has started developing strategies necessary to refine those goals and track performance over the 20-year IMP planning period. Potential dry weather, wet weather, and system renewal goals and KPIs that the City may consider implementing in their program going forward were identified during this evaluation but specific goals were not finalized. Appropriate goals and KPIs will be developed over time as the IMP is implemented and more data become available.

Potential capital and programmatic alternatives and planning level costs were identified to characterize the expected additional level of investment required to address collection system needs, anticipated regulatory drivers, and City goals over the 20-year IMP planning period. Cost estimates include potential additional capital, operation and maintenance, and necessary planning or data collection costs. Estimates were developed for three potential funding level scenarios and 10 project categories. The three funding levels represent increasingly proactive investments that the City could pursue to make infrastructure upgrades and water quality improvements through the IMP.

Results of the alternatives evaluation indicate that between $170 million and $340 million of additional investment will be needed to address wastewater collection system needs over the IMP planning period (Table 1). In subsequent analyses, these cost estimates will be combined with estimates for the wastewater treatment and stormwater collection system and evaluated to identify the level of investment that appropriately balances overall costs with anticipated community benefits. These subsequent evaluations will also consider impacts on future residential utility bills and community-wide affordability.

Table 1. Summary of Collection System Capital and Programmatic Costs, in 2017 Dollars.

Project Categories	20-Year Funding Scenario		
	Level 1	**Level 2**	**Level 3**
Wet Weather Program Planning and Management	$5,690,000	$7,490,000	$12,580,000
Asset Management Support	$1,350,000	$2,700,000	$4,500,000
System Renewal and Public I/I Reduction	$50,072,000	$74,162,000	$81,422,000
System Capacity Enhancement and I/I Private Reduction	$47,342,000	$71,342,000	$101,342,000
Building Backup Alleviation	$500,000	$5,000,000	$40,000,000
Private Common Collector Elimination	$5,932,000	$9,098,000	$12,265,000
System Expansion	$37,117,000	$48,117,000	$59,117,000
Cleaning Program	$2,840,000	$2,877,000	$5,680,000
Pump Station Repair and Rehabilitation (R/R)	$1,914,000	$3,954,000	$3,954,000
Annual Sewer Improvements	$18,000,000	$18,000,000	$18,000,000
Total	**$170,757,000**	**$242,740,000**	**$338,860,000**
Additional Staff*	**Engineer (2) Technician** (2)**	**Engineer (2) Technician (7)**	**Engineer (4) Technician (9)**
Additional Equipment	**Cleaning Truck (1) Field Truck (1)**	**Cleaning Truck (1) CCTV Truck (1) Field Truck (3)**	**Cleaning Truck (2) CCTV Truck (1) Field Truck (4)**

*Additional staff estimates include only those staff for which the Utility would incur additional costs. The estimates do not include existing or currently planned staff. These staffing estimates (and associated costs) were developed for initial IMP planning purposes. Future staffing levels, as well as specific positions, should be reevaluated as the IMP progresses over time.

**In this table, the term “technician” refers to all operators, inspectors, and technicians.

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Technical Memorandum 5

Attachments

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Attachment A. Detailed Cost Forecasts

Table A.1. Level 1 Collection System Capital and Programmatic Cost Forecast, in 2017 Dollars. Estimates include potential additional capital, operation and maintenance, and planning costs over the IMP planning period. Because the City's 2018 budget is already in development, the IMP assumes that no additional funding would be dedicated to any of the three levels described above until 2019. *Note that costs were allocated to specific years for planning purposes only and help facilitate comparisons between the alternative levels. Actual annual costs and timing of projects will be addressed in the final IMP.*

Columbia Collection System Capital and Programmatic Cost Estimates - Level 1 Service										
Project Category	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**
Wet-Weather Program Planning and Management	$ -	$ -	$ 505,000	$ 680,000	$ 280,000	$ 280,000	$ 280,000	$ 280,000	$ 280,000	$ 280,000
Asset Management	$ -	$ -	$ 75,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000
System Renewal Program	$ -	$ -	$ 2,700,000	$ 2,700,000	$ 3,441,030	$ 3,211,163	$ 2,700,000	$ 2,700,000	$ 2,700,000	$ 2,920,000
System Capacity Enhancement	$ -	$ -	$ 5,862,251	$ 2,000,000	$ 4,543,200	$ 2,000,000	$ 2,317,900	$ 2,809,320	$ 5,809,650	$ 2,000,000
Building Backup Allevation	$ -	$ -	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ -	$ -	$ -
Private Common Collector Elimination	$ -	$ -	$ 885,000	$ 945,000	$ 935,000	$ 211,111	$ 211,111	$ 211,111	$ 211,111	$ 211,111
System Expansion	$ -	$ -	$ 1,560,000	$ -	$ 2,750,000	$ 83,388	$ 10,000,000	$ -	$ 724,045	$ 2,000,000
Cleaning Program	$ -	$ -	$ 380,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000
Pump Station R/R	$ -	$ -	$ -	$ 252,450	$ 885,358	$ -	$ -	$ -	$ -	$ -
Other - Annual Sewer Improvement Cost	$ -	$ -	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000
Annual Total	**$ -**	**$ -**	**$ 13,067,251**	**$ 7,882,450**	**$ 14,139,588**	**$ 7,090,662**	**$ 16,814,011**	**$ 7,205,431**	**$ 10,929,806**	**$ 8,616,111**
Cumulative Total	**$ -**	**$ -**	**$ 13,067,251**	**$ 20,949,701**	**$ 35,089,289**	**$ 42,179,951**	**$ 58,993,962**	**$ 66,199,393**	**$ 77,129,199**	**$ 85,745,311**

Columbia Collection System Capital and Programmatic Cost Estimates - Level 1 Service										
Project Category	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**
Wet-Weather Program Planning and Management	$ 280,000	$ 280,000	$ 305,000	$ 280,000	$ 280,000	$ 280,000	$ 280,000	$ 280,000	$ 280,000	$ 280,000
Asset Management	$ 75,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000
System Renewal Program	$ 2,700,000	$ 2,700,000	$ 2,700,000	$ 2,700,000	$ 2,700,000	$ 2,700,000	$ 2,700,000	$ 2,700,000	$ 2,700,000	$ 2,700,000
System Capacity Enhancement	$ 2,000,000	$ 2,000,000	$ 2,000,000	$ 2,000,000	$ 2,000,000	$ 2,000,000	$ 2,000,000	$ 2,000,000	$ 2,000,000	$ 2,000,000
Building Backup Allevation	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Private Common Collector Elimination	$ 211,111	$ 211,111	$ 211,111	$ 211,111	$ 211,111	$ 211,111	$ 211,111	$ 211,111	$ 211,111	$ 211,111
System Expansion	$ 2,000,000	$ 2,000,000	$ 2,000,000	$ 2,000,000	$ 2,000,000	$ 2,000,000	$ 2,000,000	$ 2,000,000	$ 2,000,000	$ 2,000,000
Cleaning Program	$ 130,000	$ 130,000	$ 380,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000
Pump Station R/R	$ -	$ -	$ -	$ -	$ 776,220	$ -	$ -	$ -	$ -	$ -
Other - Annual Sewer Improvement Cost	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000
Annual Total	**$ 8,396,111**	**$ 8,396,111**	**$ 8,671,111**	**$ 8,396,111**	**$ 9,172,331**	**$ 8,396,111**	**$ 8,396,111**	**$ 8,396,111**	**$ 8,396,111**	**$ 8,396,111**
Cumulative Total	**$ 94,141,422**	**$ 102,537,533**	**$ 111,208,644**	**$ 119,604,755**	**$ 128,777,086**	**$ 137,173,197**	**$ 145,569,308**	**$ 153,965,419**	**$ 162,361,531**	**$ 170,757,642**

Table A.2. Level 2 Collection System Capital and Programmatic Cost Forecast, in 2017 Dollars. Estimates include potential additional capital, operation and maintenance, and planning costs over the IMP planning period. Because the City's 2018 budget is already in development, the IMP assumes that no additional funding would be dedicated to any of the three levels described above until 2019. *Note that costs were allocated to specific years for planning purposes only and help facilitate comparisons between the alternative levels. Actual annual costs and timing of projects will be addressed in the final IMP.*

Columbia Collection System
Capital and Programmatic Cost Estimates - Level 2 Service

Project Category	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Wet-Weather Program Planning and Management	$ -	$ -	$ 605,000	$ 780,000	$ 380,000	$ 380,000	$ 380,000	$ 380,000	$ 380,000	$ 380,000
Asset Management	$ -	$ -	$ 150,000	$ 150,000	$ 150,000	$ 150,000	$ 150,000	$ 150,000	$ 150,000	$ 150,000
System Renewal Program	$ -	$ -	$ 4,305,000	$ 4,005,000	$ 4,746,030	$ 4,516,163	$ 4,005,000	$ 4,005,000	$ 4,005,000	$ 4,225,000
System Capacity Enhancement	$ -	$ -	$ 3,862,251	$ -	$ 2,543,200	$ 4,000,000	$ 4,317,900	$ 4,809,320	$ 7,809,650	$ 4,000,000
Building Backup Allevation			$ 500,000	$ 500,000	$ 500,000	$ 500,000	$ 500,000	$ 500,000	$ 500,000	$ 500,000
Private Common Collector Elimination	$ -	$ -	$ 885,000	$ 945,000	$ 935,000	$ 422,222	$ 422,222	$ 422,222	$ 422,222	$ 422,222
System Expansion	$ -	$ -	$ 1,560,000	$ -	$ 2,750,000	$ 83,388	$ 10,000,000	$ -	$ 724,045	$ 3,000,000
Cleaning Program	$ -	$ -	$ 417,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000
Pump Station R/R	$ -	$ -	$ -	$ 372,450	$ 1,005,358	$ 120,000	$ 120,000	$ 120,000	$ 120,000	$ 120,000
Other - Annual Sewer Improvement Cost	$ -	$ -	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000
Annual Total	**$ -**	**$ -**	**$ 13,284,251**	**$ 7,882,450**	**$ 14,139,588**	**$ 11,301,773**	**$ 21,025,122**	**$ 11,516,542**	**$ 15,240,917**	**$ 13,927,222**
Cumulative Total	**$ -**	**$ -**	**$ 13,284,251**	**$ 21,166,701**	**$ 35,306,289**	**$ 46,608,062**	**$ 67,633,184**	**$ 79,149,727**	**$ 94,390,644**	**$ 108,317,866**

Columbia Collection System
Capital and Programmatic Cost Estimates - Level 2 Service

Project Category	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036
Wet-Weather Program Planning and Management	$ 380,000	$ 380,000	$ 405,000	$ 380,000	$ 380,000	$ 380,000	$ 380,000	$ 380,000	$ 380,000	$ 380,000
Asset Management	$ 150,000	$ 150,000	$ 150,000	$ 150,000	$ 150,000	$ 150,000	$ 150,000	$ 150,000	$ 150,000	$ 150,000
System Renewal Program	$ 4,005,000	$ 4,005,000	$ 4,305,000	$ 4,005,000	$ 4,005,000	$ 4,005,000	$ 4,005,000	$ 4,005,000	$ 4,005,000	$ 4,005,000
System Capacity Enhancement	$ 4,000,000	$ 4,000,000	$ 4,000,000	$ 4,000,000	$ 4,000,000	$ 4,000,000	$ 4,000,000	$ 4,000,000	$ 4,000,000	$ 4,000,000
Building Backup Allevation	$ 500,000	$ 500,000								
Private Common Collector Elimination	$ 422,222	$ 422,222	$ 422,222	$ 422,222	$ 422,222	$ 422,222	$ 422,222	$ 422,222	$ 422,222	$ 422,222
System Expansion	$ 3,000,000	$ 3,000,000	$ 3,000,000	$ 3,000,000	$ 3,000,000	$ 3,000,000	$ 3,000,000	$ 3,000,000	$ 3,000,000	$ 3,000,000
Cleaning Program	$ 130,000	$ 130,000	$ 380,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000
Pump Station R/R	$ 120,000	$ 120,000	$ 120,000	$ 120,000	$ 896,220	$ 120,000	$ 120,000	$ 120,000	$ 120,000	$ 120,000
Other - Annual Sewer Improvement Cost	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000
Annual Total	**$ 13,707,222**	**$ 13,707,222**	**$ 13,782,222**	**$ 13,207,222**	**$ 13,983,442**	**$ 13,207,222**	**$ 13,207,222**	**$ 13,207,222**	**$ 13,207,222**	**$ 13,207,222**
Cumulative Total	**$ 122,025,088**	**$ 135,732,311**	**$ 149,514,533**	**$ 162,721,755**	**$ 176,705,197**	**$ 189,912,419**	**$ 203,119,642**	**$ 216,326,864**	**$ 229,534,086**	**$ 242,741,308**

Table A.3. Level 3 Collection System Capital and Programmatic Cost Forecast, in 2017 Dollars. Estimates include potential additional capital, operation and maintenance, and planning costs over the IMP planning period. Because the City's 2018 budget is already in development, the IMP assumes that no additional funding would be dedicated to any of the three levels described above until 2019. *Note that costs were allocated to specific years for planning purposes only and help facilitate comparisons between the alternative levels. Actual annual costs and timing of projects will be addressed in the final IMP.*

Columbia Collection System
Capital and Programmatic Cost Estimates - Level 3 Service

Project Category	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Wet-Weather Program Planning and Management	$ -	$ -	$ 910,000	$ 1,060,000	$ 660,000	$ 660,000	$ 660,000	$ 660,000	$ 660,000	$ 660,000
Asset Management	$ -	$ -	$ 250,000	$ 250,000	$ 250,000	$ 250,000	$ 250,000	$ 250,000	$ 250,000	$ 250,000
System Renewal Program	$ -	$ -	$ 625,000	$ 325,000	$ 1,066,030	$ 5,736,163	$ 5,225,000	$ 5,225,000	$ 5,225,000	$ 5,445,000
System Capacity Enhancement	$ -	$ -	$ 3,862,251	$ -	$ 2,543,200	$ 6,000,000	$ 6,317,900	$ 6,809,320	$ 9,809,650	$ 6,000,000
Building Backup Allevation	$ -	$ -	$ 4,000,000	$ 4,000,000	$ 4,000,000	$ 4,000,000	$ 4,000,000	$ 4,000,000	$ 4,000,000	$ 4,000,000
Private Common Collector Elimination	$ -	$ -	$ 885,000	$ 945,000	$ 935,000	$ 633,333	$ 633,333	$ 633,333	$ 633,333	$ 633,333
System Expansion	$ -	$ -	$ 1,560,000	$ -	$ 2,750,000	$ 83,388	$ 10,000,000	$ -	$ 724,045	$ 4,000,000
Cleaning Program	$ -	$ -	$ 760,000	$ 260,000	$ 260,000	$ 260,000	$ 260,000	$ 260,000	$ 260,000	$ 260,000
Pump Station R/R	$ -	$ -	$ -	$ 372,450	$ 1,005,358	$ 120,000	$ 120,000	$ 120,000	$ 120,000	$ 120,000
Other - Annual Sewer Improvement Cost	$ -	$ -	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000
Annual Total	**$ -**	**$ -**	**$ 13,852,251**	**$ 8,212,450**	**$ 14,469,588**	**$ 18,742,884**	**$ 28,466,233**	**$ 18,957,653**	**$ 22,682,028**	**$ 22,368,333**
Cumulative Total	**$ -**	**$ -**	**$ 13,852,251**	**$ 22,064,701**	**$ 36,534,289**	**$ 55,277,173**	**$ 83,743,407**	**$ 102,701,060**	**$ 125,383,088**	**$ 147,751,422**

Columbia Collection System
Capital and Programmatic Cost Estimates - Level 3 Service

Project Category	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036
Wet-Weather Program Planning and Management	$ 660,000	$ 660,000	$ 710,000	$ 660,000	$ 660,000	$ 660,000	$ 660,000	$ 660,000	$ 660,000	$ 660,000
Asset Management	$ 250,000	$ 250,000	$ 250,000	$ 250,000	$ 250,000	$ 250,000	$ 250,000	$ 250,000	$ 250,000	$ 250,000
System Renewal Program	$ 5,225,000	$ 5,225,000	$ 5,525,000	$ 5,225,000	$ 5,225,000	$ 5,225,000	$ 5,225,000	$ 5,225,000	$ 5,225,000	$ 5,225,000
System Capacity Enhancement	$ 6,000,000	$ 6,000,000	$ 6,000,000	$ 6,000,000	$ 6,000,000	$ 6,000,000	$ 6,000,000	$ 6,000,000	$ 6,000,000	$ 6,000,000
Building Backup Allevation	$ 4,000,000	$ 4,000,000								
Private Common Collector Elimination	$ 633,333	$ 633,333	$ 633,333	$ 633,333	$ 633,333	$ 633,333	$ 633,333	$ 633,333	$ 633,333	$ 633,333
System Expansion	$ 4,000,000	$ 4,000,000	$ 4,000,000	$ 4,000,000	$ 4,000,000	$ 4,000,000	$ 4,000,000	$ 4,000,000	$ 4,000,000	$ 4,000,000
Cleaning Program	$ 260,000	$ 260,000	$ 760,000	$ 260,000	$ 260,000	$ 260,000	$ 260,000	$ 260,000	$ 260,000	$ 260,000
Pump Station R/R	$ 120,000	$ 120,000	$ 120,000	$ 120,000	$ 896,220	$ 120,000	$ 120,000	$ 120,000	$ 120,000	$ 120,000
Other - Annual Sewer Improvement Cost	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000
Annual Total	**$ 22,148,333**	**$ 22,148,333**	**$ 18,998,333**	**$ 18,148,333**	**$ 18,924,553**	**$ 18,148,333**	**$ 18,148,333**	**$ 18,148,333**	**$ 18,148,333**	**$ 18,148,333**
Cumulative Total	**$ 169,899,755**	**$ 192,048,088**	**$ 211,046,422**	**$ 229,194,755**	**$ 248,119,308**	**$ 266,267,642**	**$ 284,415,975**	**$ 302,564,308**	**$ 320,712,642**	**$ 338,860,975**

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Columbia Wastewater and Stormwater IMP

Attachment L

Our Columbia Waters
Integrated Management Plan
Wastewater & Stormwater

Technical Memorandum 6 *Wastewater Treatment Alternatives*

Columbia Wastewater and Stormwater Integrated Management Plan

Columbia, Missouri
January 5, 2018

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Section 1. Introduction

The City of Columbia, Missouri (City) is working to develop an Integrated Management Plan (IMP) for the City's wastewater and stormwater utilities. The goal of the IMP is to develop an adaptable and affordable long-term plan that addresses the City's wastewater and stormwater management needs and meets Clean Water Act requirements. The IMP will be developed based on guidance presented in US Environmental Protection Agency's (EPA) *Integrated Municipal Stormwater and Wastewater Planning Approach Framework* (Stoner 2012).

Early in the IMP process, the City and their project team worked to evaluate the City's environmental resources and infrastructure assets to better define the existing condition, performance, and needs of its systems. Results from these efforts were documented in the following technical memoranda:

- Technical Memorandum 1 – Surface Water Quality and Biological Conditions
- Technical Memorandum 2 – Wastewater Collection System Assessment
- Technical Memorandum 3 – Wastewater Treatment System Assessment
- Technical Memorandum 4 – Stormwater System Assessment

These needs assessments were useful in guiding initial prioritization of potential wastewater and stormwater improvements. Priorities were further refined during a series of community outreach meetings. Information developed from these activities formed the basis for identifying potential capital and programmatic alternatives that should be evaluated as part of the IMP. Outcomes from these efforts have been documented in the following technical memoranda:

- Technical Memorandum 5 – Wastewater Collection System Alternatives
- Technical Memorandum 6 – Wastewater Treatment System Alternatives
- Technical Memorandum 7 – Stormwater System Alternatives

The purpose of this memorandum is to describe the assumptions and methods used to develop potential funding requirements for addressing future wastewater treatment needs at the Columbia Regional Wastewater Treatment Plant (CRWWTP).

Given the inherent uncertainty associated with the regulatory environment, as well as data gaps identified in the existing systems analysis, the alternatives outlined in this memorandum are only intended to serve as planning level estimates. These alternatives and associated costs should be refined as additional information is developed and sanitary sewer system improvements are made during future phases of the IMP. Findings from the wastewater treatment system alternatives analysis are documented in the sections that follow.

Section 2. Treatment Alternative Costs

In December 2016, representatives from the City, HDR Engineering, Inc. (HDR), and Black and Veatch, Inc. (B&V), met to discuss and identify treatment alternatives necessary to improve existing operations at the CRWWTP; address regulatory drivers related to the wet-weather program, disinfection, nutrient removal, and more stringent ammonia limits; and continue to provide for efficient and effective treatment practices. The following treatment plant improvements were identified during that meeting:

- Wet Weather Capacity Improvements
- Expanded Nitrification Capacity
- Biological Nutrient Removal
- Chemical Disinfection
- Constructed Wetlands Improvements
- Biosolids System Improvements
- Alternate Effluent Outfall Location

Planning level capital and operations and maintenance (O&M) costs were developed for these alternatives by updating estimates from the City's 2004 Sanitary Sewer Utility Facilities Planning Report (2004 Master Plan), as well as using recent HDR and B&V experience with similar projects in the region. HDR met with City staff on March 8 to review and confirm information and assumptions used to formulate the final alternatives presented in this memorandum.

2.1 Wet Weather Capacity Improvements

Inflow and infiltration into the City's sewer system has caused sewer backups and overflows for decades. A sewer system evaluation survey completed in 1978 identified inflow and infiltration flows in excess of 48 million gallons per day during a storm with a 5 year frequency and 4.5 hour duration. The reports from the 1978 survey recommended immediate rehabilitation of portions of the sewer collection system. In addition, the 1978 survey recommended expansion of the City's maintenance program to include continuing system rehabilitation to prevent additional inflow and infiltration due to deterioration of the system. The City's maintenance program was not expanded and inflow and infiltration has continued to increase, nearing 140 million gallons per day during a heavy rainfall event. Increased inflow and infiltration burdens the collection system and wastewater treatment plant, resulting in sewer overflows and backups into buildings.

Since 2014, significant collection system rehabilitation and inflow and infiltration reduction projects have been completed. In addition, sewer maintenance and operations personnel have completed repairs and equipment modifications and implemented operational changes at the WWTP that have significantly reduced sewer overflows along the major trunk sewers, mostly near the wastewater treatment plant. Despite these recent improvements, the wastewater treatment plant is currently unable to manage peak wet weather flows in a manner that effectively limits the number of SSOs within the collection system during very large events. As mentioned in TM 5, wet weather LOS goals for the collection system will be developed by the City and a design storm will be determined. When wet weather flows from the selected design storm result in a peak flow that exceeds design capacities of the individual treatment processes at the WWTP, pumping capacity improvements, process expansion or storage of the excess flows will be required. For infrequent wet weather flows, storage options are typically more cost effective. However, there are some process scenarios or pumping solutions that may address treatment requirements and overflow reduction needs more effectively that need to be evaluated while keeping in mind the reality that there will always be some rainfall events that result in sewer overflows.

Several treatment and storage alternatives are available to potentially address peak wet weather flows. For planning purposes, a peak mechanical plant capacity of 50.4 million gallons per day (MGD) (12.6 MGD per train; 4 trains) and the projected 2030 peak hourly flow rate of 143 MGD, identified in the 2004 Master Plan, were used to identify combined wet weather alternatives that would manage approximately 90 MGD of excess flow. Individual alternatives evaluated to potentially address the wet weather issues included improving influent pumping capacity, adding storage, adding peak flow clarifiers, adding chemical disinfection with an alternate outfall at Hinkson Creek near the Perche Creek confluence, and increasing conveyance capacity to the wetland treatment units (WTU). These alternatives were combined to provide a recommended approach to wet weather treatment and management.

2.1.1 Influent Pump Station Capacity Improvements

The design capacity of the existing influent pump station is not sufficient to address the 2030 peak hourly flow rate of 143 MGD that was identified in the 2004 Master Plan. The current influent pump station consists of six vertical, dry-pit, non-clog centrifugal pumps and two 5/8-inch vertical, front-cleaned bar screens with an approximately 50-foot deep wet well. According to City staff, capacity of the pump station with all pumps in service is approximately 90 MGD that can be routed to the mechanical treatment plant or to wet weather treatment.

The assumed influent pump station capacity improvements are based on doubling the existing pump station firm capacity to accept the 2030 peak hourly flow. The new pump station would be constructed of a concrete below grade structure with brick and block superstructure adjacent to and matching the existing influent pump station.

Total project cost for this alternative is $21,993,400 in 2017 dollars with approximately $121,900 anticipated in annual operations and maintenance costs. See Attachment A, Table A.1. for detailed cost estimates.

2.1.2 Wet Weather Storage

Storage is needed when wet weather flows exceed the capacity of downstream treatment process or conveyance capacities. In Columbia, storage may be added out in the collection system or at the treatment plant. Preliminary assessments indicated that collection system storage immediately upstream of the influent pump station is not cost-effective compared to storage at the treatment plant. Storage further upstream in the collection system may be cost-effective to address conveyance limitations. However, additional assessments and hydraulic modeling are needed to fully consider collection system alternatives.

Wet weather storage capacity at the treatment plant currently includes a 6.1 million gallon (MG) peak flow lagoon. The City also plans to repurpose a 6.8 MG sludge storage lagoon into excess flow storage during the first implementation period of the IMP, providing a total of 12.9 MG of wet weather storage capacity. However, the location of the existing peak flow lagoon may be needed for siting new peak flow clarifiers as discussed in the following section. Therefore, the storage provided in the existing peak flow lagoon was not included in the wet weather capacity improvement alternatives. For planning purposes, an additional 4 to 10 MG of storage depending on the combination of alternatives is estimated to provide adequate storage at the 2030 peak hourly flow rate of 143 MGD. Storage capacities were calculated by halving the excess flow rates, which is a reasonably conservative assumption in the absence of hydraulic modeling results. Total project costs to install 4 and 10 MG excess flow basins are approximately $6,250,000 and $15,600,000, respectively, in 2017 dollars. See Attachment A, Table A.2. for detailed cost estimates.

2.1.3 High Rate Wet Weather Treatment

The current wet weather treatment capacity needs to be increased as it is not adequate to address the 2030 hourly peak flow rate. The current wet weather treatment facilities consists of two 115-foot diameter clarifiers, a peak flow sludge pump station, and a 6.1 MG peak flow lagoon. At the 2030 peak hourly flow rate of 143 MGD and a peak mechanical plant capacity of 50.4 MGD, approximately 90 MGD of wet weather treatment capacity would be required without additional storage. Plant staff has observed that each peak flow clarifier is hydraulically limited to 13 MGD (1300 gpm/sf surface overflow rate; SOR). Wet weather clarifiers similar to primary clarifiers can be designed up to a SOR of 2400 gpm/sf without chemical addition and to as high as 7000 gpm/sf SOR with the addition of chemically enhanced settling (CES). Assuming no modifications to the existing wet weather clarifiers, new wet weather treatment facilities would be required to address the remaining 64 MGD of wet weather flow.

This alternative is based on the addition of one to two (depending on the storage alternative) 130-foot diameter CES clarifiers with a new solids pumping station, chemical feed building, and modifications to the existing diversion structure. Additional testing of the existing clarifiers and potential modification would be required to optimize the size and SOR design for the new clarifiers.

Space near the existing peak flow clarifiers is limited by the 100-year floodplain at elevation 581’, which may require new facilities to be constructed at the location of the existing peak flow lagoon. For these planning purposes, the existing peak flow lagoon is assumed to be decommissioned with utilization of this space for peak flow clarifiers.

Total project cost for this alternative is $11,824,200 in 2017 dollars with approximately $180,400 anticipated in annual operations and maintenance costs. Cost to construct only one peak flow clarifier is $7,809,000 in 2017 dollars with approximately $169,000 in annual operations and maintenance costs. See Attachment A, Table A.3. for detailed cost estimates.

2.1.4 Effluent Conveyance to Wetland Treatment Units

Currently flow through the process trains combines with excess flow at the diversion structure prior to flowing through a 72-inch diameter pipeline to the WTUs (approximately 2.3 miles). The current pipeline is hydraulically limited to approximately 60 MGD of gravity flow. This restriction prevents adequate management of wet weather flows. In order to convey the 2030 peak flow rate, a parallel 78-inch diameter pipe would be required. Temporary storage of wet weather flows in WTU 4 would then mitigate conveyance limitations through the remainder of the WTUs and the effluent pump station.

Total project cost for to install a second 78-inch diameter parallel pipe from the treatment plant to the WTUs is $14,800,500 in 2017 dollars with approximately $6,900 anticipated in annual operations and maintenance costs. The total conveyance capacity of this option would exceed143 MGD to the WTUs. See Attachment A, Table A.4. for detailed cost estimates.

2.1.5 Wet Weather Chemical Disinfection and Alternate Outfall

An effective wet weather management strategy could be to discharge secondary treated flows to Hinkson Creek near the Perche Creek confluence during wet weather events that exceed the hydraulic capacity of the effluent conveyance line to the WTUs. Implementation of this discharge would require effluent disinfection based on Missouri regulations. No other treatment improvements are assumed to be required due to the high receiving water flows, temporary duration of the discharge, and the high quality of the mechanical plant effluent.

Chlorination is considered the best disinfection method for this application given the infrequent nature of the discharge, disinfection effectiveness, and relatively low capital and operational costs. Dechlorination would also be needed prior to discharge. Required improvements include chemical storage and handling, a chlorination/dechlorination contact basin, intermediate pumping, effluent conveyance, and a new outfall. Total project cost for wet weather disinfection facilities is $10,053,400 in 2017 dollars and approximately $103,500 in annual operations and maintenance costs. Total project cost for the effluent conveyance and outfall structure is approximately $766,200 in 2017 dollars and approximately $6,900 in annual operations and maintenance costs. See Attachment A, Table A.5. for detailed cost estimates.

2.1.6 Wet Weather Capacity Improvements Alternatives Analysis

Combinations of the wet weather management alternatives described above were evaluated to determine the most cost-effective wet weather management approach to improve the existing facility (Figure 1). These alternatives should be reevaluated as the City develops a better understanding of wet weather peak flows and volumes. Wet weather flow monitoring and modeling, evaluation of cost-effective inflow and infiltration reductions, collection system conveyance improvements, and level of service expectations should form the basis for selection of the optimal wet weather management strategy at the CRWWTP.

The following combinations of wet weather capacity improvements were evaluated:

- Alternative A: Wet Weather Conveyance to WTUs with Additional Treatment
- Alternative B: Wet Weather Conveyance to WTUs with Additional Treatment and Storage
- Alternative C: Wet Weather Conveyance to WTUs with Additional Treatment and Discharge of Secondary Treated Flows to Hinkson Creek near Perche Creek Confluence

Capital and annual operation and maintenance costs for Alternative A were selected for IMP planning purposes since they represent the lowest cost option. All alternatives require increased wet weather influent pumping capacity and additional peak flow treatment capacity. Alternatives B and C are more costly due to the cost of increased on-site storage required to adequately treat and convey wet weather flows. Alternative C could become the most cost-effective, depending on the amount of wet weather storage needed to implement this solution. Alternative C also provides additional benefits other than the potential lowest cost option, including addition of chemical disinfection facilities that could be leveraged if further dry weather disinfection requirements are imposed, an additional outfall location to provide greater flexibilities, and reducing flows to the WTUs and Eagle Bluffs Conservation Area (EBCA) during wet weather conditions.

ALTERNATIVE A: WET WEATHER CONVEYANCE TO WTUS WITH ADDITIONAL TREATMENT

- Increase influent pumping capacity
- 2 new 130-ft CES peak flow clarifiers
- Parallel 78-inch line to the wetlands
- See Figure 2 for process flow schematic

Table 1. Construction and Operation and Maintenance Cost Estimate for Wet Weather Alternative A in 2017 Dollars.

Improvement	Flow (mgd)	Comments	Construction Cost	Additional O&M Cost
Mechanical Plant	50.4	-	-	
Peak Flow Clarifiers (Existing)	13 mgd x 2 = 26	Plant observed hydraulic limitation	-	
Peak Flow Clarifiers (New)	66.6	2 new 130 ft CES 2500 gpd/sf SOR	$11,824,200	$180,400
Peak Flow Storage	-	-	-	
Total Flow	**143**	-	-	
Influent Pumping	143	-	$21,993,400	$121,900
Conveyance	143	Parallel 78” diameter	$14,800,500	$6,900
Total			**$48,618,100**	**$309,200**

ALTERNATIVE B: WET WEATHER CONVEYANCE TO WTUS WITH ADDITIONAL TREATMENT AND STORAGE

- Increase influent pumping capacity
- 1 new 130-ft CES peak flow clarifier
- 4 million gallons (MG) of excess flow storage
- Parallel 78-inch line to the WTUs
- See Figure 3 for process flow schematic

Table 2. Construction and Operation and Maintenance Cost Estimate for Wet Weather Alternative B in 2017 Dollars.

Improvement	Flow (mgd)	Comments	Construction Cost	Additional O&M Cost
Mechanical Plant	50.4	-	-	
Peak Flow Clarifiers (Existing)	13 mgd x 2 = 26	Plant observed hydraulic limitation	-	
Peak Flow Clarifier (New)	46.6	1 new 130 ft CES 3600 gpd/sf SOR	$7,809,000	$168,990
Peak Flow Storage	20	10 MG needed, 6 MG existing, 4 MG new	$6,250,000	
Total Flow	**143**	-	-	
Influent Pumping	143	-	$21,993,400	$121,900
Conveyance	143	Parallel 78" diameter	$14,800,500	$6,900
Total			**$50,852,900**	**$297,790**

ALTERNATIVE C: WET WEATHER CONVEYANCE TO WTUS WITH ADDITIONAL TREATMENT AND DISCHARGE OF SECONDARY TREATED FLOWS TO HINKSON CREEK NEAR PERCHE CREEK CONFLUENCE WITH INCREASE OF INFLUENT PUMPING CAPACITY

- Increase influent pumping capacity
- 1 new 130-ft CES peak flow clarifiers
- 10 million gallons (MG) of excess flow storage
- Disinfection to secondary treated flow during excess wet weather flows prior to discharge to Hinkson Creek
- New effluent conveyance and outfall for secondary treated flows to Hinkson Creek during peak flows above 60 mgd
- See Figure 4 for process flow schematic

Table 3. Construction and Operation and Maintenance Cost Estimate for Wet Weather Alternative C in 2017 Dollars.

Improvement	Flow (mgd)	Comments	Construction Cost	Additional O&M Cost
Mechanical Plant	50.4	-	-	
Peak Flow Clarifiers (Existing)	13 mgd x 2 = 26	Plant observed hydraulic limitation	-	
Peak Flow Clarifier (New)	34	1 new 130 ft CES 2500 gpd/sf SOR	$7,809,000	$168,990
Peak Flow Storage	32.6	16 MG needed, 6 MG existing, 10 MG new	$15,625,000	
Total Flow	**143**	-	-	
Disinfection & Intermediate Pumping	50.4	-	$10,020,600	$46,192
Influent Pumping	143	-	$21,993,400	$121,900
Conveyance	50.4	Conveyance to Hinkson Creek at Perche Creek Confluence	$766,200	$6,900
Total			**$56,214,200**	**$343,982**

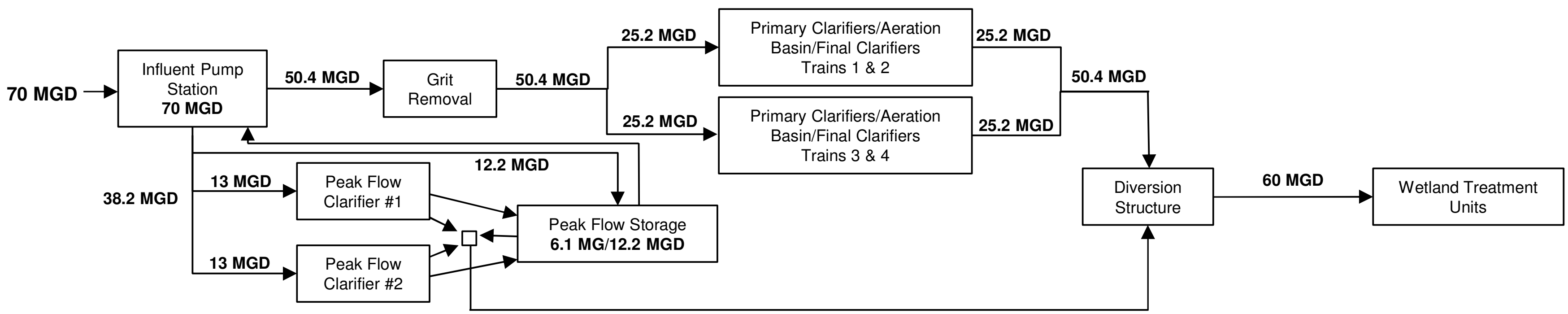

Figure 1. Process Flow Schematic for the Existing CRWWTP.

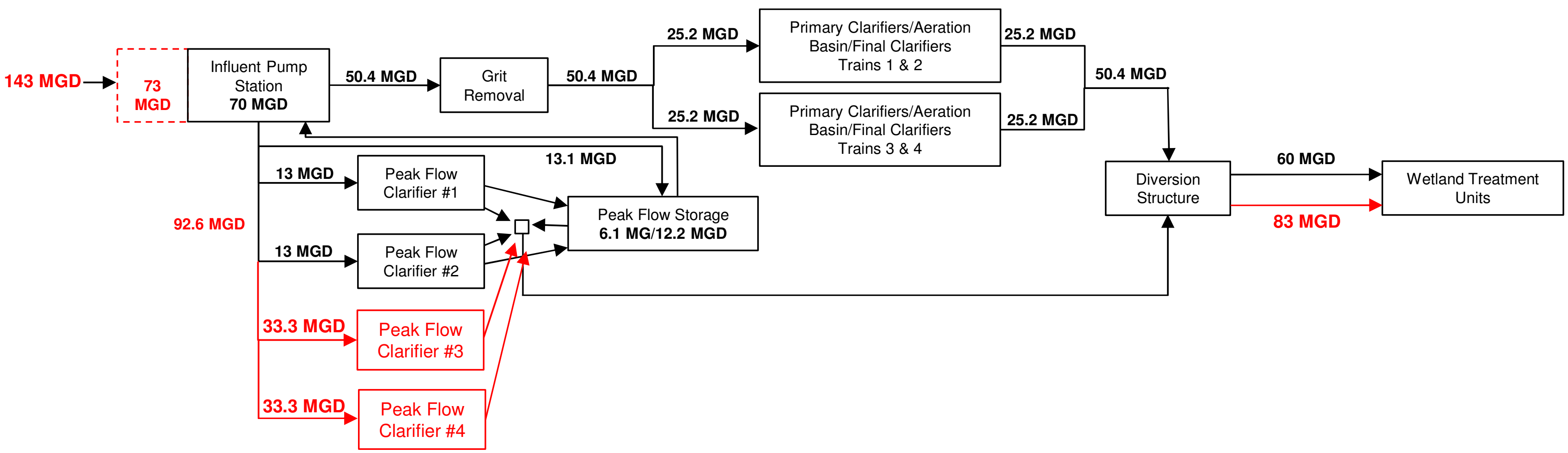

Figure 2. Process Flow Schematic for Wet Weather Alternative A.

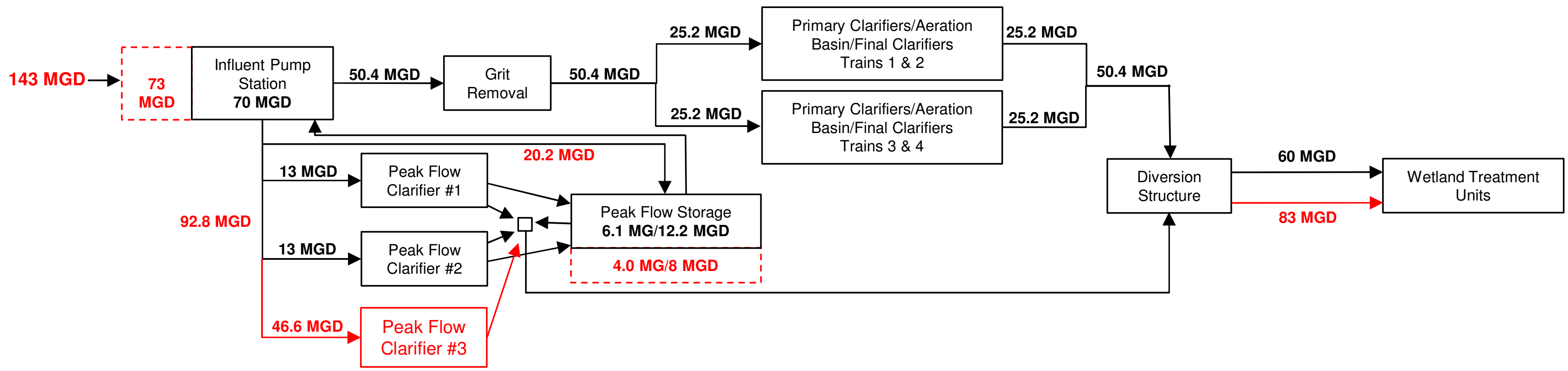

Figure 3. Process Flow Schematic for Wet Weather Alternative B.

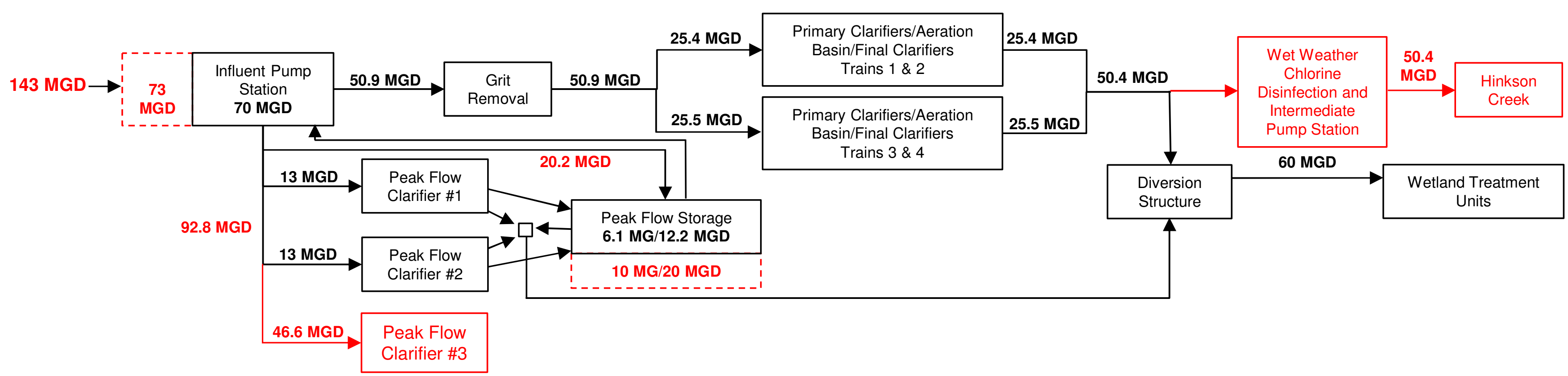

Figure 4. Process Flow Schematic for Wet Weather Alternative C.

2.2 Expanded Nitrification Capacity

In 2013, the CRWWTP was upgraded in part to meet an average monthly ammonia effluent limit of 6.0 mg/L ammonia at the design flow of 25.2 MGD. The CRWWTP was designed to meet this limit by combining the effluent from the two original trains (Trains 1 & 2) that partially nitrify with effluent from the two new trains (Trains 3 & 4) that fully nitrify. Trains 1 & 2 are each rated for biochemical oxygen demand treatment of 6.3 MGD annual average flow and 2.2 MGD annual average flow for nitrification per the 2009 Phase 1 Improvements project. Trains 3 and 4 constructed in the 2009 Phase 1 Improvements project are each rated for 6.3 MGD annual average flow for nitrification and denitrification. Under current flow conditions (approximately 15 MGD), this combination produces a high quality effluent that is generally less than 1.0 mg/L of ammonia (as nitrogen) and should be expected to maintain this performance up to approximately 17 MGD. Further process optimization may extend capacity above the 17 MGD rating.

As average flows at the CRWWTP increase over time, ammonia effluent concentrations will also increase. Future ammonia effluent limits may also be lowered due to changes in statistical assumptions that are used to calculate limits or revisions to the underlying water quality criteria on which the limits are based. During permitting discussions over the last several years, Missouri Department of Natural Resources (MDNR) staff has expressed the potential need to reevaluate the methods and data used to calculate the CRWWTP ammonia limit. These reevaluations would result in a 30% reduction in the existing effluent limit.

MDNR is also considering adopting more stringent ammonia criteria during one of the next water quality standards rule updates. These criteria were proposed by EPA in 2013 and are designed to protect freshwater mussels and snails against ammonia toxicity. Although the adoption and implementation schedule in Missouri remains unclear, these new criteria would result in a 90% reduction in the existing effluent limit.

Additional nitrification capacity will be needed if ammonia limits are reduced and average flows increase above 17 MGD. Addition of two new activated sludge treatment trains (Trains 5 & 6) would be needed to meet potential future ammonia limits (<1 mg/L NH_3 as nitrogen). New trains include primary clarifiers, primary sludge pumping station, aeration basins, final clarifiers, final sludge pumping stations, and the replacement of two existing blowers with larger units. All new buildings and structure estimates include facilities to be constructed on foundations of auger cast piles due to known soil concerns at the site. Total nitrification capacity of the plant would be increased to 29.6 MGD annual average if these two new trains are added.

Total project cost for this alternative is $38,110,000 in 2017 dollars with approximately $661,200 anticipated in annual operations and maintenance costs. See Attachment A, Table A.6. for detailed cost estimates.

2.3 Biological Nutrient Removal

Unlike ammonia, the timing and impact of nutrient drivers are somewhat less certain because statewide nutrient regulations have not yet been proposed by EPA or MDNR. MDNR has been working to develop statewide nutrient regulations since 2005. In 2011, EPA partially disapproved statewide reservoir nutrient criteria proposed by MDNR. Since that time, MDNR has been working to address the disapproval and expects to propose new reservoir criteria in 2017. These reservoir criteria will not impact the CRWWTP directly, but the scientific basis will likely set a precedent for development of stream and river criteria in the future.

The regional nature of nutrient issues in the Mississippi River Basin has led regulators to support adaptive-type approaches as a first step in reducing nutrients. In 2014, MDNR completed the Missouri Nutrient Loss Reduction Strategy (NLRS). The strategy outlines actions and adaptive management steps that will be taken to reduce nutrients over the next five years. For point sources, one of those actions includes identifying reasonable and cost-effective treatment technologies that could be implemented under future iterations of the NLRS. Among other state nutrient reduction plans, biological nutrient removal (BNR) technologies are generally targeted unless localized water quality impacts warrant more advanced treatment.

The CRWWTP is not currently required or designed to remove nutrients, although some TN and TP reduction occurs in the WTUs and EBCA wetlands before effluent is discharged to the Missouri River. However, nutrient criteria development efforts or future iterations of the NLRS could require upgrades to BNR during the IMP planning period.

Modifications to existing Trains 3 & 4 and future Trains 5 & 6 are planned for expanded nitrification capacity in order to achieve potential BNR requirements. BNR limits were assumed to be <1 mg/L ammonia as nitrogen, 10 mg/L total nitrogen, and 1 mg/L phosphorus. Modifications to Trains 1 and 2 were not included in this alternative. Implementation of this alternative would provide a total plant BNR capacity of 25.2 MGD annual average. The following items are included in this alternative:

- Preanoxic, anaerobic, and anoxic zones added to Trains 5 and 6
- Preanoxic and anaerobic zones added to Trains 3 and 4
- Modifications to existing Gravity Thickeners for use as fermenters
- Add polymer tote system for the waste activated sludge cetrifuges located in an existing building

Total project cost for this alternative is $13,564,300 in 2017 dollars with approximately $200,400 anticipated in annual operations and maintenance costs. See Attachment A, Table A.7. for detailed cost estimates.

2.4 Chemical Disinfection

The CRWWTP is not currently required or designed to chemically disinfect because bacteria criteria are not currently applied to the EBCA wetlands. However, the City has proactively measured bacteria concentrations in both the mechanical plant and final effluents. The bacteria measurements show that following the plant upgrade, the combination of the mechanical plant and the constructed treatment wetlands reduce bacteria to levels that are generally below the secondary contact recreation water quality criterion of 1134 colony forming units per 100 milliliters (CFU/100mL) of *Escherichia coli (E. coli*).

In 2012, EPA modified the federal recreational water quality criteria. These recommendations no longer allow states to implement tiered primary contact recreational uses, as is currently the case in Missouri, and are silent on the appropriateness of secondary contact recreation criteria. Missouri has not yet adopted the 2012 criteria but have indicated that they will during a future water quality standards update. EPA is also currently considering the use of F-specific and somatic coliphages as possible indicators of fecal contamination in ambient water. There is evidence to suggest that coliphages, which are a subset of bacteriophages (viruses that infect bacteria), are better indicators of human health risk than traditional fecal bacteria. Coliphage-based criteria may have operational implications for wastewater treatment facilities because UV disinfection alone may not be sufficiently effective at typical dosage rates.

Adoption of these new criteria at the state level could result in stringent bacteria effluent limits for the CRWWTP. For planning purposes, both ultraviolet (UV) and chlorine disinfection alternatives were evaluated. However, chlorine disinfection has several distinct advantages over UV disinfection at the CRWWTP. First, chlorine disinfection is more cost-effective and less operationally intense than UV. Chlorine is also a more effective disinfectant for bacteria and particularly viruses. For planning purposes, it was assumed that chlorine will be added to the mechanical plant effluent using the conveyance line to the WTUs to provide the required chlorine contact time. It is also assumed that chlorine residuals will dissipate within the WTUs prior to discharge to Eagle Bluffs. See Attachment A, Table A.8. and A.9. for detailed disinfection cost estimates. Note that estimates included for chlorine disinfection in Table A.9. assume that chlorination facilities detailed in Table A.4. are not implemented as part of the wet weather capacity improvements. If these disinfection facilities are implemented as part of the wet weather capacity improvements, then capital costs will be less than those included in Table A.8. because the wet weather facilities can be leveraged to implement disinfection of the remaining flows.

2.5 Constructed Wetlands Improvements

The constructed WTUs provide additional treatment of mechanical plant effluent prior to discharge to Eagle Bluffs. Wastewater is discharged from the mechanical plant to Unit 4, and then flows by gravity through Units 1, 2, and 3. The WTUs enhance the overall treatment process by using physical, biological, and chemical processes to remove pollutants like organics, nutrients, ammonia, metals, and bacteria. These processes improve effluent quality and facilitate compliance with effluent discharge limits. Given these important water quality benefits, it is necessary to ensure that sufficient funding is available to maintain proper operation and maintenance of these structures.

The original WTUs 1, 2, and 3 have been in operation since 1994. In 2001, WTU 4 was added to increase overall capacity of the wetlands. In 2008, the City conducted a study to estimate solids accumulation in WTUs 4 and 1. These WTUs were evaluated because they are the first two wetlands in the series and therefore, would most likely be impacted by settling solids. The 2008 study found that sludge depth averaged less than a foot across the wetland cells in those WTUs. An extrapolation of those 2008 data suggests that as of 2016, sludge depth has increased to approximately 1.8 feet in WTU 4 and 1.6 feet in WTU 1. The sludge in these WTUs should be removed to ensure that the wetlands continue to provide effective wastewater treatment.

Sludge removal costs include costs associated with removing existing vegetation ($4,800/WTU cell), removing and disposing existing sludge ($500/dry ton) and replanting vegetation ($24,000/WTU cell). Current sludge depths and volumes were estimated using data collected by the City in 2008.

The existing WTUs were constructed using an earthen liner. The useful life of an earthen liner can vary significantly depending on the materials used, thickness, and hydrology of the site, but can generally be expected to average approximately 30 years. Little data is currently available regarding existing WTU liner integrity. For planning purposes however, it was assumed that the liner in WTU 1 should be replaced over the IMP period. Liner replacement was limited to WTU 1 because it is one of the oldest units and provides significant treatment benefits due to its size and location in the wetland series. Lining costs for Unit 1 ($938,000/WTU cell) were estimated based on experience from comparable projects in the Midwest. The City should evaluate liner integrity in all of the WTUs to better refine these assumptions going forward.

Total project cost for removing sludge in WTUs 1 and 4, and replacing the liner in WTU 1 is $23,593,000 in 2017 dollars. See Attachment A, Table A.10. for detailed cost estimates.

2.6 Biosolids System Improvements

There are no new regulatory drivers for these projects. However, digester rehabilitation and capacity enhancements must be completed to address aging infrastructure and ensure sound operation of the existing facility. Current solids treatment at the plant consists of three 60-foot diameter primary digesters and one 60-foot diameter secondary digester. Waste activated sludge is thickened through two centrifuges and primary sludge is thickened in two 25-foot diameter gravity thickeners prior to combining in the primary digesters. Any peak flow sludge is also sent through the gravity thickeners prior to digestion. Digested sludge is sent to two dewatering centrifuges prior to land application. Solids are dewatered to approximately 25% solids.

Digester Rehabilitation: This alternative includes new fixed steel covers for the primary digesters, new floating steel cover for the secondary digester, pumped mixing systems added for primary digesters, and odor reduction improvements. Cleaning and inspection of the digesters was included in the costs.

Total project cost for this alternative is $8,711,700 in 2017 dollars.

New Primary Digester: Solids analysis from the 2008 Conceptual Design Report indicates that digester capacity is not sufficient for Class B compliance (10 day solids retention rate) at 2030 max month conditions. Additional capacity may be necessary within the next 10 to 15 years but will depend on the actual organic loading increases over that time. This alternative includes costs for a new 60-foot concrete primary digester with a fixed steel cover, pumped mixing, digester heating system, odor control, and a new digester building.

Total project cost for this alternative is $4,234,000 in 2017 dollars with approximately $49,100 anticipated in annual operations and maintenance costs.

See Attachment A, Table A.11. and A.12. for detailed cost estimates.

2.7 Alternate Effluent Outfall

The City of Columbia has reclaimed wastewater effluent for maintenance of water levels in EBCA since the early 1990s. This arrangement has provided MDC a valuable reclaimed water source rather than pumping water from the Missouri River, which would add significant long-term operational and maintenance costs and jeopardize the economic viability of EBCA. However, the City may reconsider this arrangement if increased regulatory pressures such as more stringent ammonia criteria drive additional treatment requirements. Instead of discharging to EBCA, the City could move the discharge to the Missouri River to take advantage of large dilution flows.

The estimated cost to install a new 72-inch diameter pipe from the WTUs to the Missouri River (approximately 1.5 miles) is $10,567,300 in 2017 dollars with approximately $6,900 anticipated in annual operations and maintenance costs. If an alternate effluent outfall to the Missouri River is implemented, disinfection and potentially nutrient removal should also be considered. Given the current beneficial arrangement between the City and MDC and the lack of pressing regulatory drivers that would require additional treatment investments, costs for construction of an alternate outfall to the Missouri River were not considered through the remainder of this planning process.

See Attachment A, Table A.13. for detailed cost estimates.

Section 4. Funding Scenario Development

For the CRWWTP, planning level estimates were identified to characterize the level of investment required to improve existing operations, address future regulatory drivers, and provide for more sustainable treatment practices over the next 20 years (the IMP planning period). It is important to note that these estimates represent the investments and activities needed in addition to the resources the Sewer Utility currently manages. Three potential funding level scenarios were used to guide the analysis. They are broadly defined as follows:

- **Level 1 Funding (Level 1) –** Funding needed to **provide the minimum** LOS that meets both community-wide expectations and **existing** regulatory requirements over the 20-year IMP planning period.
- **Level 2 Funding (Level 2) –** Funding needed to **exceed the minimum** LOS based that meets community-wide expectations and **more proactively** meets existing regulatory requirements over the 20-year IMP planning period.
- **Level 3 Funding (Level 3) –** Funding needed to **address all** forecasted infrastructure needs and proactively meet **both** existing and forecasted regulatory requirements over the 20-year IMP planning period.

The estimates include potential capital costs, operation and maintenance costs, and costs associated with necessary planning or data collection activities needed over the IMP planning period. The resulting total and annual spending differences between each funding level presented above are the product of assumptions related to the total project implementation cost, project scheduling, and the timing of known regulatory drivers.

For the wastewater treatment system, the nominal capital and O&M costs estimated within each project category was assumed to be equal across the three funding levels; total cost differences between levels resulted from implementing projects earlier during the IMP planning period (Level 3) as opposed to later (Level 1) to address known regulatory drivers or infrastructure needs. For example, the total cost for expanded nitrification capacity in Level 3 ($46 million) is approximately $6.0 million more than in Level 1 ($40 million) because Level 3 assumes expanded nitrification capacity to meet stringent ammonia discharge requirements will be required 10 years earlier than in Level 1. The $6.0 million difference reflects the additional 10 years of O&M costs that result from implementing the project earlier.

Assumptions related to the timing of wastewater treatment system improvements for each of the three funding levels are presented in Attachment B, Table B.1. Detailed cost forecasts for each funding level are presented in Attachment B, Tables B.2. through B.4.

Section 5. Summary

The City, HDR, and B&V worked to identify wastewater treatment system improvements that would be needed to improve existing operations at the CRWWTP and address regulatory drivers over the 20-year IMP planning period. Alternatives include improving wet-weather capacity, implementing chemical disinfection, installing biological nutrient removal, enhancing nitrification capacity, and providing for more sustainable treatment practices.

Potential capital and programmatic alternatives and planning level costs were identified to characterize the expected additional level of investment that would be needed to fund these improvements. Cost estimates include potential additional capital, operation and maintenance, and necessary planning or data collection costs. Estimates were developed for three potential funding level scenarios and six project categories. The three funding levels represent increasingly proactive investments that the City could pursue to make infrastructure upgrades and water quality improvements through the IMP.

Results of the alternatives evaluation indicate that between $132 million and $158 million of additional investment will be needed to address wastewater treatment system needs over the IMP planning period (**Table 4**). In subsequent analyses, these cost estimates will be combined with estimates for the wastewater collection and stormwater systems and evaluated to identify the level of investment that appropriately balances overall costs with anticipated community benefits. These subsequent evaluations will also consider impacts on future residential utility bills and community-wide affordability.

Table 4. Summary of Wastewater Treatment System Capital and Programmatic Costs in 2017 Dollars.

Project Categories	20-Year Funding Scenario		
	Level 1	**Level 2**	**Level 3**
Wet Weather Capacity Improvements	$50,164,000	$51,710,000	$52,329,000
Expanded Nitrification Capacity	$40,094,000	$41,416,000	$46,044,000
Biological Nutrient Removal	$0	$13,965,000	$14,967,000
Chemical Disinfection	$4,481,000	$5,088,000	$7,210,000
Constructed Wetlands Improvements	$23,593,000	$23,593,000	$23,593,000
Digester Rehabilitation	$8,712,000	$8,712,000	$8,712,000
Digester Capacity Improvements	$4,823,000	$4,823,000	$4,823,000
Total	**$131,867,000**	**$149,307,000**	**$157,678,000**

Technical Memorandum 6

Attachments

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Attachment A. Wastewater Treatment Alternatives Costs

Table A.1. Influent Pump Station Capacity Improvements Capital and Operation and Maintenance Cost Estimates in 2017 Dollars.

Capital Costs	Unit Price	Total
Expand Influent Pump Station		$9,260,100
Electrical/I&C	20%	$1,852,100
Mechanical	7%	$648,300
Sitework	15%	$1,389,100
General Requirements	10%	$926,100
Contingency	25%	$3,519,000
Total Construction Cost		**$17,594,700**
ELA	25%	$4,398,700
Total Project Cost		**$21,993,400**

O&M Costs	Unit Price	Unit	Qty	Total
Power	0.08	$/kwh	544,282	$43,600
Natural Gas	0.83	$/therm		
Labor-Operators	40	$/hr	520	$20,800
Labor-Maintenance	40	$/hr	78	$3,100
Equipment Maintenance	2%	of equipment cost	2,720,703	$54,400
Total O&M Cost				**$121,900**

Table A.2. Excess Flow Basin Capital Cost Estimates in 2017 Dollars.

Capital Costs	Unit Price	Total
4 MG basin		$4,000,000
Surface Aerators		$0
Electrical/I&C	20%	$0
Mechanical	7%	$0
Sitework	15%	$0
General Requirements	10%	$0
Contingency	25%	$1,000,000
Total Construction Cost		**$5,000,000**
ELA	25%	$1,250,000
Total Project Cost		**$6,250,000**

Capital Costs	Unit Price	Total
10 MG basin		$10,000,000
Surface Aerators		$0
Electrical/I&C	20%	$0
Mechanical	7%	$0
Sitework	15%	$0
General Requirements	10%	$0
Contingency	25%	$2,500,000
Total Construction Cost		**$12,500,000**
ELA	25%	$3,125,000
Total Project Cost		**$15,625,000**

Table A.3. High Rate Wet Weather Treatment Capital and Operation and Maintenance Cost Estimates in 2017 Dollars.

Capital Costs	Unit Price	Total
Add 1 new 130' CEPT Basins		$1,430,000
Additional I/I Sludge Pump Station		$704,900
CEPT Chemical Feed Building		$1,103,000
Diversion Structure Modifications		$50,000
Electrical/I&C	20%	$657,600
Mechanical	7%	$230,200
Sitework	15%	$493,200
General Requirements	10%	$328,800
Contingency	25%	$1,249,500
Total Construction Cost		**$6,247,200**
ELA	25%	$1,561,800
Total Project Cost		**$7,809,000**

O&M Costs	Unit Price	Unit	Qty	Total
Power	0.08	$/kwh	11,817	$940
Natural Gas	0.83	$/therm		
Labor-Operators	40	$/hr	40	$1,600
Labor-Maintenance	40	$/hr	10	$400
Equipment Maintenance	1%	quipment	423,375	$8,450
Chemicals				
Ferric Chloride	1.27	$/gal	95,606	$121,700
Polymer	2.5	$/lb	34,221	$35,900
Total O&M Cost				**$168,990**

Capital Costs	Unit Price	Total
Add 2 new 130' CEPT Basins		$2,860,000
Additional I/I Sludge Pump Station		$965,500
CEPT Chemical Feed Building		$1,103,000
Diversion Structure Modifications		$50,000
Electrical/I&C	20%	$995,700
Mechanical	7%	$348,500
Sitework	15%	$746,800
General Requirements	10%	$497,900
Contingency	25%	$1,891,900
Total Construction Cost		**$9,459,300**
ELA	25%	$2,364,900
Total Project Cost		**$11,824,200**

O&M Costs	Unit Price	Unit	Qty	Total
Power	0.08	$/kwh	23,633	$1,880
Natural Gas	0.83	$/therm		
Labor-Operators	40	$/hr	80	$3,200
Labor-Maintenance	40	$/hr	20	$800
Equipment Maintenance	1%	of equipment cost	846,751	$16,900
Chemicals				
Ferric Chloride	1.27	$/gal	95,606	$121,700
Polymer	1.05	$/lb	34,221	$35,900
Total O&M Cost				**$180,400**

Table A.4. Parallel Line to WTUs Capital and Operation and Maintenance Cost Estimates in 2017 Dollars.

Capital Costs	Unit Price	Total
78" Diameter, 2.3 miles		$8,611,100
Electrical/I&C	0%	$0
Mechanical	0%	$0
Sitework	0%	$0
General Requirements	10%	$861,200
Contingency	25%	$2,368,100
Total Construction Cost		**$11,840,400**
ELA	25%	$2,960,100
Total Project Cost		**$14,800,500**

O&M Costs	Unit Price	Unit	Qty	Total
Power	0.08	$/kwh	0	$0
Natural Gas	0.83	$/therm	0	$0
Labor-Operators	40	$/hr	48	$1,900
Labor-Maintenance	40	$/hr	1	$5,000
Equipment Maintenance	2%	of equipment cost	0	$0
Total O&M Cost				**$6,900**

Table A.5. Wet Weather Chemical Disinfection and Alternate Outfall Capital and Operation and Maintenance Cost Estimates in 2017 Dollars.

5b1 - Chlorination - Wet Weather Facility

Capital Costs	50.4 MGD	
Chlor/DeChlor Disinfection Facility at Mechani(		$2,245,600
Intermediate Pumping Station		$2,283,500
Electrical/I&C	20%	$905,800
Mechanical	7%	$317,000
Sitework	15%	$679,400
General Requirements	10%	$452,900
Contingency	25%	$1,132,300
Total Construction Cost		**$8,016,500**
ELA	25%	$2,004,100
Total Project Cost		**$10,020,600**

O&M Costs	Unit Price	Unit	Qty	Total
Power	0.08	$/kwh		$86
Natural Gas	0.83	$/therm		
Labor-Operators	40	$/hr		
Labor-Maintenance	40	$/hr		
Equipment Maintenance				
Chemicals				
Sodium Hypochlorite	1.00	$/gal	2,019	$40,390
Sodium Bisulfite	0.17	$/lb	1,681	$5,717
Total O&M Cost				**$46,192**

Line to Hinkson (78" Diameter, 500 feet)

Capital Costs	Unit Price	Total
78" Diameter, 500 feet		$354,600
Effluent Structure		$100,200
Electrical/I&C	0%	$0
Mechanical	0%	$0
Sitework	0%	$0
General Requirements	10%	$35,500
Contingency	25%	$122,600
Total Construction Cost		**$612,900**
ELA	25%	$153,300
Total Project Cost		**$766,200**

O&M Costs	Unit Price	Unit	Qty	Total
Power	0.08	$/kwh	Qty	$0
Natural Gas	0.83	$/therm	0	$0
Labor-Operators	40	$/hr	48	$1,900
Labor-Maintenance	5000		1	$5,000
Total O&M Cost				**$6,900**

Table A.6. Nitrification Capital and Operation and Maintenance Cost Estimates in 2017 Dollars.

Capital Costs	Unit Price	Total
Primary clarifiers (5 & 6) - 105 ft Diameter		$2,306,200
New Aeration Basins (5 & 6) (deduct anoxic zor		$4,792,700
Final Clarifier (trains 5&6)- 115 ft Diameter		$2,660,600
RAS/WAS Pump Stations (train 5&6)		$1,200,000
Primary Sludge Pump Station (for Train 3)		$704,900
Primary Sludge Pump Station (for Train 4)		$260,600
Blower Replacement		$846,800
Piles		$3,274,300
Electrical/I&C	20%	$3,209,300
Mechanical	7%	$1,123,300
Sitework	15%	$2,407,000
General Requirements	10%	$1,604,700
Contingency	25%	$6,097,600
Total Construction Cost		**$30,488,000**
ELA	25%	$7,622,000
Total Project Cost		**$38,110,000**

O&M Costs	Unit Price	Unit	Qty	Total
Power	0.08	$/kwh	6,949,385	$555,900
Natural Gas	0.83	$/therm		
Labor-Operators	40	$/hr	520	$20,800
Labor-Maintenance	40	$/hr	338	$13,500
Equipment Maintenance	2%	of equipment cost	3,549,085	$71,000
Total O&M Cost				**$661,200**

Table A.7. Biological Nutrient Removal Capital and Operation and Maintenance Cost Estimates in 2017 Dollars.

Capital Costs	Unit Price	Total
Add Anaerobic/Preanoxic zones		$4,007,300
Utilize Gravity Thickeners for Fermentation		$90,000
Add Anoxic zones to Trains 5 & 6		$1,516,800
Polymer Tote System (Chemical feed System*)		$97,000
Electrical/I&C	20%	$1,142,300
Mechanical	7%	$399,800
Sitework	15%	$856,700
General Requirements	10%	$571,200
Contingency	25%	$2,170,300
Total Construction Cost		**$10,851,400**
ELA	25%	$2,712,900
Total Project Cost		**$13,564,300**

O&M Costs	Unit Price	Unit	Qty	Total
Power	0.08	$/kwh	1,483,436	$118,700
Natural Gas	0.83	$/therm		
Labor-Operators	40	$/hr	520	$20,800
Labor-Maintenance	40	$/hr	702	$28,100
Equipment Maintenance	2%	of equipment cost	918,833	$18,400
Chemicals				
Ferric Chloride	1.27	$/gal		
Polymer	1.05	$/lb	13,700	$14,400
Total O&M Cost				**$200,400**

Table A.8. Chlorine Disinfection Capital and Operation and Maintenance Cost Estimates in 2017 Dollars. Estimates assume that improvements outlined in Table A4 are not implemented.

Capital Costs		143 MGD
Chlor/DeChlor Disinfection Facility at Mechanical Plant		$1,768,000
Intermediate Pumping Station		$0
Electrical/I&C	20%	$353,600
Mechanical	7%	$123,800
Sitework	15%	$265,200
General Requirements	10%	$176,800
Contingency	25%	$442,000
Total Construction Cost		**$3,129,400**
ELA	25%	$442,000
Total Project Cost		**$3,571,400**

O&M Costs	**Unit Price**	**Unit**	**Qty**	**Total**
Power	0.08	$/kwh		$1,116
Natural Gas	0.83	$/therm		
Labor-Operators	40	$/hr		
Labor-Maintenance	40	$/hr		
Equipment Maintenance				
Chemicals				
Sodium Hypochlorite	1.00	$/gal	1,162	$302,122
Sodium Bisulfite	0.17	$/lb	0	$0
Total O&M Cost				**$303,237**

Table A.9. Ultraviolet Disinfection Capital and Operation and Maintenance Cost Estimates in 2017 Dollars.

Capital Costs	**Unit Price**	**Total**
UV Disinfection Facility at WLPS		$7,658,000
Intermediate Pumping Station		$5,625,811
Electrical/I&C	20%	$2,656,800
Mechanical	7%	$929,900
Sitework	15%	$1,992,600
General Requirements	10%	$1,328,400
Contingency	25%	$5,047,900
Total Construction Cost		**$25,239,411**
ELA	25%	$6,309,900
Total Project Cost		**$31,549,311**

O&M Costs	**Unit Price**	**Unit**	**Qty**	**Total**
Power	0.08	$/kwh	380,464	$30,400
Natural Gas	0.83	$/therm		
Labor-Operators	40	$/hr	520	$20,800
Labor-Maintenance	40	$/hr	348	$13,900
Equipment Maintenance	450	$/lamp	70	$23,000
Total O&M Cost				**$88,100**

Table A.10. Constructed Wetlands Improvements Capital Cost Estimates in 2017 Dollars.

Capital Costs	Unit Price	Total
Total Cells		13
Sludge Removal and Lining Cost		$17,004,000
Cattail Removal Cost		$62,400
Cattail Planting Cost		$312,000
Contingency	30%	$5,214,300
Total Construction Cost		**$22,592,700**
ELA		$1,000,000
Total Project Cost		**$23,592,700**

Table A.11. Digester Rehabilitation Capital and Operation and Maintenance Cost Estimates in 2017 Dollars.

Capital Costs	Unit Price	Total
Drain, clean and inspect digester interior		$160,000
Removal and disposal of existing 60' dia fixed/f		$160,000
Secondary Cover		$700,000
Primary Covers (3) replacement		$1,555,700
Odor Control		$194,200
Primary Digester Mixing		$1,028,600
Electrical/I&C	20%	$695,700
Mechanical	7%	$243,500
Sitework	15%	$521,800
General Requirements	10%	$379,900
Contingency	25%	$1,329,900
Total Construction Cost		**$6,969,300**
ELA	25%	$1,742,400
Total Project Cost		**$8,711,700**

O&M Costs	Unit Price	Unit	Qty	Total
Power	0.08	$/kwh	0	$0
Natural Gas	0.83	$/therm		
Labor-Operators	40	$/hr	0	$0
Labor-Maintenance	40	$/hr	0	$0
Equipment Maintenance	2%	of equipment cost	0	$0
Total O&M Cost				**$0**

Table A.12. Digester Capacity Improvements Capital and Operation and Maintenance Cost Estimates in 2017 Dollars.

Capital Costs	Unit Price	Total
Primary Cover		$518,600
Odor Control		$64,800
Primary Digester Mixing		$342,900
Concrete		$352,800
Heating		$48,700
New Building		$386,500
Electrical/I&C	20%	$342,900
Mechanical	7%	$120,100
Sitework	15%	$257,200
General Requirements	10%	$171,500
Contingency	25%	$677,500
Total Construction Cost		**$3,387,200**
ELA	25%	$846,800
Total Project Cost		**$4,234,000**

O&M Costs	Unit Price	Unit	Qty	Total
Power	0.08	$/kwh	434,467	$34,800
Natural Gas	0.83	$/therm		
Labor-Operators	40	$/hr	40	$5,200
Labor-Maintenance	40	$/hr	40	$1,300
Equipment Maintenance	2%	of equipment cost	391,600	$7,800
Total O&M Cost				**$49,100**

Table A.13. New Line from WTUs to Missouri River Capital and Operation and Maintenance Cost Estimates in 2017 Dollars.

Capital Costs	Unit Price	Total
72" Diameter, 1.5 miles pipeline		$6,047,900
Effluent Structure		$100,200
Electrical/I&C	0%	$0
Mechanical	0%	$0
Sitework	0%	$0
General Requirements	10%	$614,900
Contingency	25%	$1,690,800
Total Construction Cost		**$8,453,800**
ELA	25%	$2,113,500
Total Project Cost		**$10,567,300**

O&M Costs	Unit Price	Unit	Qty	Total
Power	0.08	$/kwh	0	$0
Natural Gas	0.83	$/therm	0	$0
Labor-Operators	40	$/hr	48	$1,900
Labor-Maintenance	5000		1	$5,000
Total O&M Cost				**$6,900**

Attachment B. 20-Year Funding Scenarios

Table B.1. Wastewater Treatment System Improvement Timing Assumptions. The dark blue represents initiation of capital expenditures and light blue represents ongoing O&M expenditures.

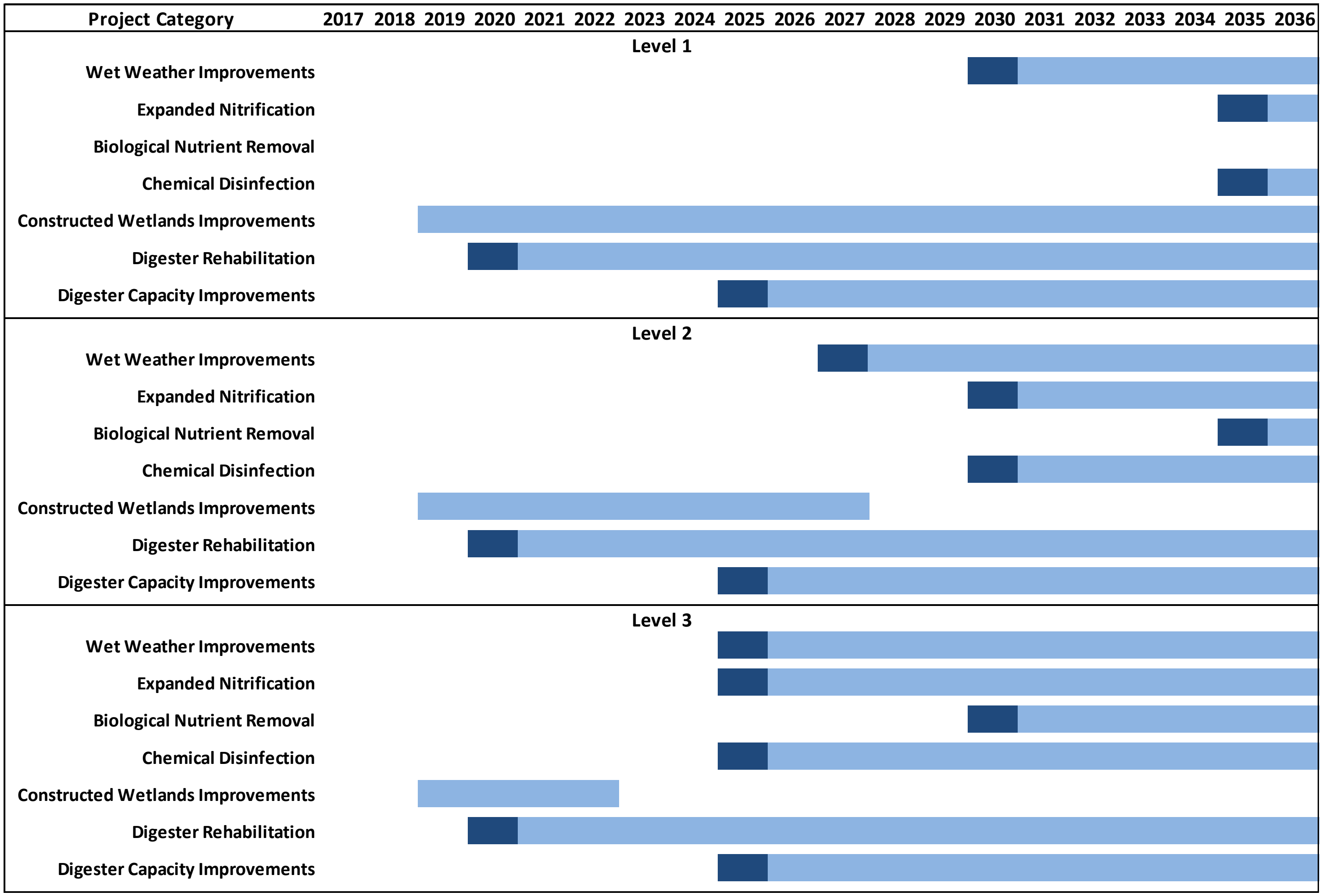

Table B.2. Level 1 Wastewater Treatment System Capital and Programmatic Cost Forecast in 2017 Dollars.

Columbia Wastewater Treatment System
Capital and Programmatic Cost Estimates - Level 1 Funding

Project Category	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Wet Weather Improvements	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Expanded Nitrification	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Biological Nutrient Removal	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Chemical Disinfection	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Constructed Wetlands Improvements	$ -	$ -	$ 1,310,707	$ 1,310,706	$ 1,310,706	$ 1,310,706	$ 1,310,706	$ 1,310,706	$ 1,310,706	$ 1,310,706
Digester Rehabilitation	$ -	$ -	$ -	$ 8,849,700	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000
Digester Capacity Improvements	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 4,283,100	$ 49,100
Annual Total	**$ -**	**$ -**	**$ 1,310,707**	**$ 10,160,406**	**$ 1,448,706**	**$ 1,448,706**	**$ 1,448,706**	**$ 1,448,706**	**$ 5,731,806**	**$ 1,497,806**
Cumulative Total	**$ -**	**$ -**	**$ 1,310,707**	**$ 11,471,113**	**$ 12,919,819**	**$ 14,368,525**	**$ 15,817,231**	**$ 17,265,937**	**$ 22,997,743**	**$ 24,495,549**

Columbia Wastewater Treatment System
Capital and Programmatic Cost Estimates - Level 1 Funding

Project Category	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036
Wet Weather Improvements	$ -	$ -	$ -	$ 48,927,300	$ 309,200	$ 309,200	$ 309,200	$ 309,200	$ 309,200	$ 309,200
Expanded Nitrification	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 38,771,200	$ 661,200
Biological Nutrient Removal	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Chemical Disinfection	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 3,874,637	$ 303,237
Constructed Wetlands Improvements	$ 1,310,706	$ 1,310,706	$ 1,310,706	$ 1,310,706	$ 1,310,706	$ 1,310,706	$ 1,310,706	$ 1,310,706	$ 1,310,706	$ 1,310,706
Digester Rehabilitation	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000
Digester Capacity Improvements	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100
Annual Total	**$ 1,497,806**	**$ 1,497,806**	**$ 1,497,806**	**$ 50,425,106**	**$ 1,807,006**	**$ 1,807,006**	**$ 1,807,006**	**$ 1,807,006**	**$ 44,452,843**	**$ 2,771,443**
Cumulative Total	**$ 25,993,355**	**$ 27,491,161**	**$ 28,988,967**	**$ 79,414,073**	**$ 81,221,079**	**$ 83,028,085**	**$ 84,835,091**	**$ 86,642,097**	**$ 131,094,940**	**$ 133,866,383**

Table B.3. Level 2 Wastewater Treatment System Capital and Programmatic Cost Forecast in 2017 Dollars.

Columbia Wastewater Treatment System Capital and Programmatic Cost Estimates - Level 2 Funding										
Project Category	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**
Wet Weather Improvements	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Expanded Nitrification	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Biological Nutrient Removal	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Chemical Disinfection	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Constructed Wetlands Improvements	$ -	$ -	$ 2,621,411	$ 2,621,411	$ 2,621,411	$ 2,621,411	$ 2,621,411	$ 2,621,411	$ 2,621,411	$ 2,621,411
Digester Rehabilitation	$ -	$ -	$ -	$ 8,849,700	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000
Digester Capacity Improvements	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 4,283,100	$ 49,100
Annual Total	**$ -**	**$ -**	**$ 2,621,411**	**$ 11,471,111**	**$ 2,759,411**	**$ 2,759,411**	**$ 2,759,411**	**$ 2,759,411**	**$ 7,042,511**	**$ 2,808,511**
Cumulative Total	**$ -**	**$ -**	**$ 2,621,411**	**$ 14,092,522**	**$ 16,851,933**	**$ 19,611,344**	**$ 22,370,756**	**$ 25,130,167**	**$ 32,172,678**	**$ 34,981,189**

Columbia Wastewater Treatment System Capital and Programmatic Cost Estimates - Level 2 Funding										
Project Category	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**
Wet Weather Improvements	$ 48,927,300	$ 309,200	$ 309,200	$ 309,200	$ 309,200	$ 309,200	$ 309,200	$ 309,200	$ 309,200	$ 309,200
Expanded Nitrification	$ -	$ -	$ -	$ 38,771,200	$ 661,200	$ 661,200	$ 661,200	$ 661,200	$ 661,200	$ 661,200
Biological Nutrient Removal	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 13,764,700	$ 200,400
Chemical Disinfection	$ -	$ -	$ -	$ 3,874,637	$ 303,237	$ 303,237	$ 303,237	$ 303,237	$ 303,237	$ 303,237
Constructed Wetlands Improvements	$ 2,621,411	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Digester Rehabilitation	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000
Digester Capacity Improvements	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100
Annual Total	**$ 51,735,811**	**$ 496,300**	**$ 496,300**	**$ 43,142,137**	**$ 1,460,737**	**$ 1,460,737**	**$ 1,460,737**	**$ 1,460,737**	**$ 15,225,437**	**$ 1,661,137**
Cumulative Total	**$ 86,717,000**	**$ 87,213,300**	**$ 87,709,600**	**$ 130,851,737**	**$ 132,312,474**	**$ 133,773,211**	**$ 135,233,948**	**$ 136,694,685**	**$ 151,920,122**	**$ 153,581,259**

Table B.4. Level 3 Wastewater Treatment System Capital and Programmatic Cost Forecast in 2017 Dollars.

Columbia Wastewater Treatment System Capital and Programmatic Cost Estimates - Level 3 Funding										
Project Category	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**
Wet Weather Improvements	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 48,927,300	$ 309,200
Expanded Nitrification	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 38,771,200	$ 661,200
Biological Nutrient Removal	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Chemical Disinfection	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 3,874,637	$ 303,237
Constructed Wetlands Improvements	$ -	$ -	$ 5,898,175	$ 5,898,175	$ 5,898,175	$ 5,898,175	$ -	$ -	$ -	$ -
Digester Rehabilitation	$ -	$ -	$ -	$ 8,849,700	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000
Digester Capacity Improvements	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 4,283,100	$ 49,100
Annual Total	**$ -**	**$ -**	**$ 5,898,175**	**$ 14,747,875**	**$ 6,036,175**	**$ 6,036,175**	**$ 138,000**	**$ 138,000**	**$ 95,994,237**	**$ 1,460,737**
Cumulative Total	**$ -**	**$ -**	**$ 5,898,175**	**$ 20,646,050**	**$ 26,682,225**	**$ 32,718,400**	**$ 32,856,400**	**$ 32,994,400**	**$ 128,988,637**	**$ 130,449,374**

Columbia Wastewater Treatment System Capital and Programmatic Cost Estimates - Level 3 Funding										
Project Category	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**
Wet Weather Improvements	$ 309,200	$ 309,200	$ 309,200	$ 309,200	$ 309,200	$ 309,200	$ 309,200	$ 309,200	$ 309,200	$ 309,200
Expanded Nitrification	$ 661,200	$ 661,200	$ 661,200	$ 661,200	$ 661,200	$ 661,200	$ 661,200	$ 661,200	$ 661,200	$ 661,200
Biological Nutrient Removal	$ -	$ -	$ -	$ 13,764,700	$ 200,400	$ 200,400	$ 200,400	$ 200,400	$ 200,400	$ 200,400
Chemical Disinfection	$ 303,237	$ 303,237	$ 303,237	$ 303,237	$ 303,237	$ 303,237	$ 303,237	$ 303,237	$ 303,237	$ 303,237
Constructed Wetlands Improvements	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Digester Rehabilitation	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000
Digester Capacity Improvements	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100
Annual Total	**$ 1,460,737**	**$ 1,460,737**	**$ 1,460,737**	**$ 15,225,437**	**$ 1,661,137**	**$ 1,661,137**	**$ 1,661,137**	**$ 1,661,137**	**$ 1,661,137**	**$ 1,661,137**
Cumulative Total	**$ 131,910,111**	**$ 133,370,848**	**$ 134,831,585**	**$ 150,057,022**	**$ 151,718,159**	**$ 153,379,296**	**$ 155,040,433**	**$ 156,701,570**	**$ 158,362,707**	**$ 160,023,844**

Columbia Wastewater and Stormwater IMP

Attachment M

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Our Columbia Waters
Integrated Management Plan
Wastewater & Stormwater

Technical Memorandum 7 *Stormwater System Alternatives*

Columbia Wastewater and Stormwater Integrated Management Plan

Columbia, Missouri
January 5, 2018

HDR

Geosyntec consultants
Shockey Consulting Services, llc
TREKK Design Group, LLC

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Section 1. Introduction and Objectives

The City of Columbia, Missouri (City) is working to develop an Integrated Management Plan (IMP) for the City's wastewater and stormwater utilities. The goal of the IMP is to develop an adaptable and affordable long-term plan that addresses the City's wastewater and stormwater management needs and meets Clean Water Act requirements. The IMP will be developed based on guidance presented in US Environmental Protection Agency's (EPA) *Integrated Municipal Stormwater and Wastewater Planning Approach Framework*[1].

Early in the IMP process, the City and their project team worked to evaluate the City's environmental resources and infrastructure assets to better define the existing condition, performance, and needs of its systems. Results from these efforts were documented in the following technical memoranda:

- Technical Memorandum 1 – Surface Water Quality and Biological Conditions
- Technical Memorandum 2 – Wastewater Collection System Assessment
- Technical Memorandum 3 – Wastewater Treatment System Assessment
- Technical Memorandum 4 – Stormwater System Assessment

These needs assessments were useful in guiding initial prioritization of potential wastewater and stormwater improvements. Priorities were further refined during a series of community outreach meetings. Information developed from these activities formed the basis for identifying potential capital and programmatic alternatives that should be evaluated as part of the IMP. Outcomes from these efforts have been documented in the following technical memoranda:

- Technical Memorandum 5 – Wastewater Collection System Alternatives
- Technical Memorandum 6 – Wastewater Treatment System Alternatives
- Technical Memorandum 7 – Stormwater System Alternatives
- Technical Memorandum 8 – Community Outreach Results

The purpose of this memorandum is to describe the assumptions and methods used to develop potential IMP alternatives for addressing stormwater system needs. Capital and programmatic needs were identified in Technical Memorandum 4 (TM4) . Most critically, the evaluation highlighted the fact that the current level of asset management investment is not sufficient to address existing needs. Currently, approximately 15% of pipes in the system are beyond their physical effective life (PEL). This number is expected to grow to nearly 60% over the next 20 years at the current renewal rate. The assessment findings also indicated that only 1% of the pipes and 7% of the structures have been inspected and assigned a condition rating. Continued underfunding and deferment of system replacement, renewal, and assessment activities will reduce system function and reliability.

These asset renewal issues contribute to public health, safety, and water quality concerns. Flooding is a critical health and safety issue in the City; the City's historical customer complaint

[1] Stoner, N. and C. Giles. 2012. Integrated Municipal Stormwater and Wastewater Planning Approach Framework. June 5, 2012. Washington D.C.

database includes nearly 2,700 reports of street, house, and yard flooding. The City has addressed many of these issues but several areas with a relatively high concentration of flooding reports remain. Approximately 60% of the City's annual stormwater budget is spent resolving flooding issues, as well as making emergency repairs to address dangerous pipe collapses and roadway failures. Improving and maintaining water quality in area streams and lakes is also a significant concern for the Utility and City residents. The Missouri Department of Natural Resources (MDNR) has identified seven water quality impairments in the City that are caused by urban and other nonpoint source runoff.

Alternatives to address these capital and programmatic needs were developed by HDR Engineering, Inc. (HDR), and Geosyntec Consultants, Inc. (Geosyntec), based on information gathered regarding current system performance, Utility staff goals, estimated implementation costs, and community priorities. Representatives from HDR and Geosyntec then met with City staff on January 27 and March 8, 2017 to review and confirm information and assumptions used to formulate the alternatives presented in this memorandum.

Given the uncertainties and data gaps identified during the stormwater system assessment, the alternatives outlined in this memorandum are only intended to serve as planning level estimates. These alternatives and associated costs should be refined as additional information is developed during future phases of the IMP. Results from the stormwater system alternatives assessment are documented in the sections that follow.

Section 2. Stormwater System Goals

In 2008, the City funded a study to evaluate the stormwater program with respect to applicable regulations, current and future program goals, and potential funding options (CH2MHill 2008). Goals were identified and prioritized through a workshop approach with stakeholders from the community. The final 2008 prioritized goals were as follows:

1. Provide Public Safety
2. Maintain the Stormwater Conveyance System
3. Adequately Fund, Staff, and Organize the Stormwater Utility
4. Provide Environmental Protection without Unreasonable Economic Burdens
5. Improve Environmental Integrity and Reduce Flooding
6. Regulatory Compliance

As part of the IMP alternative development process, HDR and Geosyntec reviewed these goals with City staff and confirmed that they still generally reflect the overall goals and objectives of the Stormwater Utility. However, the group decided that the original six goals could logically be re-categorized and reduced to four goals which still capture the priorities outlined in the 2008 study. The four goals are:

1. Provide Public Safety
2. Improve Environmental Integrity
3. Renew and Maintain the Stormwater Conveyance System
4. Adequately Fund and Staff the Stormwater Utility

The City believes that developing and implementing their stormwater program to achieve these four goals will help ensure that public health protections are maintained, level of service (LOS) goals are achieved, and environmental protections are economically sensible. In addition to redefining the goals, key performance indicators (KPIs) that could aid in evaluating how effectively the City achieves the goals were also discussed. These KPIs will be evaluated and refined through future iterations of the IMP. Brief descriptions of each goal, along with suggested KPIs, are included in the sections that follow.

2.1 Provide Public Safety

The City's highest stormwater priority is to provide services that maintain public health, welfare, and safety. From a stormwater perspective, the greatest threats to public safety include infrastructure failures such as street collapses and flooding. The City is currently focused on providing services to address these two specific issues but current funding levels do not address the overall needs. For example, the City has identified over $30 million worth of stormwater projects to reduce flooding, increase capacity, and make other system improvements. However, funding for these projects has averaged only $316,000 per year over the last three years. Improving system renewal and assessment management activities will aid in addressing public safety and flood reduction, but at the current level of funding public safety-related projects will continue to be deferred.

As the City continues to develop and implement their program over time, several KPIs could be used to better track progress in achieving public safety goals. These KPIs include:

- Identifying and tracking the number of street closures due to flooding or infrastructure failures.
- Identifying and tracking the number of flooding complaints organized by storm size.

2.2 Improve Environmental Integrity

In addition to providing for the public health, welfare, and safety of the community, another important goal for the Stormwater Utility is to provide a minimum level of environmental protection and improve environmental integrity in areas that have already been impacted. These goals include compliance with the City's municipal separate storm sewer system (MS4) permit and implementation of existing (Hinkson Creek Collaborative Adaptive Management) or future total maximum daily loads (TMDLs) to address water quality impairments.

Since 2008, the City has made progress towards achieving these goals by refining the Stormwater Management & Water Quality Manual (Columbia 2009), implementing a stream buffer ordinance, and coordinating installation of more than 400 water quality best management practices (BMPs). However, there are areas across the City that have historically been impacted by flooding and erosion that should be addressed to improve attainment of this goal.

Existing regulatory requirements are outlined in the City's MS4 permit. The City, Boone County, and University of Missouri jointly hold the permit and are collectively responsible for compliance with permit conditions through implementation of a stormwater management program. Although the co-permittees are in compliance with their permit, some programmatic elements of the current stormwater management program could be refined to improve program effectiveness and water quality conditions in the City. These elements include pursuing a more strategic and proactive visual inspection program to identify illicit discharges, refining standards and BMP design requirements, improving data management, and improving construction site runoff inspection procedures.

New and evolving requirements and regulations targeted to improve water quality will strain the Utility's already limited resources. As outlined in Technical Memorandum 1, there are a number of potential future regulatory requirements that will impact stormwater management activities in the City. For example, future water quality criteria changes and regulations governing how permit requirements should be expressed will impact the City's MS4 permit and program. Many new regulatory requirements will also be related to the implementation of existing and future TMDLs aimed at addressing aquatic life and bacteria impairments. These TMDLs could drive stream stabilization and runoff treatment improvements to address water quality conditions.

Potential KPIs for measuring progress towards attaining environmental integrity goals include tracking:

- Stream miles evaluated per year,
- Number of outfalls and frequency of inspections,
- Detention cell and BMP inspections,

- Construction site inspections,
- Length of unstable stream banks in the City, and
- Number of water quality impairments attributed to storm water runoff by MDNR in the City and MS4 area.

2.3 Renew and Maintain the Stormwater Conveyance System

As noted in Section 1, the City currently spends significant time and resources making emergency repairs to the stormwater conveyance system. As a result, there is a significant backlog (approximately 23 miles) of structurally deficient pipes in need of rehabilitation or replacement. Improving maintenance and assessment activities will enable effective and efficient project planning and facilitate attainment of the other system goals.

Currently the City uses closed-circuit television (CCTV) primarily for the sanitary collection system. However, opportunities exist to expand CCTV use for the stormwater system. For example, specifications have recently been revised to require that all new stormwatwer facilities be inspected using CCTV prior to acceptance by the City. By integrating stormwater CCTV observations with the City's information management system, the City can more efficiently make decisions at the asset level. This allows for data driven forecasting of short- and long-term renewal needs for management of the stormwater system and aids in prioritizing future CCTV and system renewal efforts. As the City continues to move forward with the inspection and rehabilitation of the stormwater system, using the data to inform an asset management based process for prioritization of inspection and renewal activities will help ensure the City focuses their resources where they provide the most benefit.

To fully assess the stormwater conveyance system, a stormwater master plan should be developed to aid in identifying and prioritizing improvement locations. Computer models provide much of the data needed to assess the capacity of the stormwater conveyance system. Currently, the City has a hydraulic analysis model for the regulatory floodplain which includes the open channel portions of the drainage system. However, conveyance system models have not been completed for critical areas of concern. Resources are required to build models, collect data for calibrating the models, and for applying the models to generate the necessary information for decision-making.

Potential KPIs for measuring progress towards attaining conveyance system maintenance goals include tracking:

- Annual system renewal,
- Inspection progress,
- Number and cost of emergency repairs, and
- Pipe and structure ages.

2.4 Adequately Fund and Staff the Stormwater Utility

Without sufficient funding, the City cannot fully meet the aforementioned goals or provide the level of service expected by the community. In 2015, voters approved a measure to increase stormwater charges by approximately 25% per year through 2020, but investment needs still exceed the available funding.

The Utility's 2017 budget of $2.2 million is intended to address aging infrastructure, flood reduction, and water quality improvements across the City. However, this budget is insufficient to address existing needs in any one, let alone all three, of these areas. For example, current backlog of stormwater infrastructure beyond its PEL is approximately $50 million. Even if the entire existing budget were devoted to addressing this backlog, renewal needs will continue to increase over the next 20 years due to the age and material of many pipes and structures in the system. With the resources currently available, necessary system renewal, flood reduction, and water quality improvement activities must be deferred. This deferment will make the system less reliable, less safe, and will increase the number and cost of emergency repairs going forward.

In the future, the Utility may want to develop specific financial and management KPIs to measure progress towards meeting this goal. In the interim however, progress can be measured with the same KPIs that will be tracked for the public safety, environmental integrity, and conveyance system maintenance goals described previously. Consistent progress as measured by those KPIs would suggest that the Utility is adequately funding and staffing program activities, whereas a lack of progress could suggest that additional funding and staffing may be needed.

Section 3. Funding Scenario Development

As mentioned previously, uncertainties and data gaps in the stormwater system preclude the development of specific project recommendations or alternatives. Instead, planning level estimates were identified to characterize the expected additional level of investment required to address system needs, anticipated regulatory drivers, and City goals over the next 20 years. These estimates represent the investments and activities needed **in addition to** resources the Stormwater Utility currently manages.

Three potential funding level scenarios were used to guide the analysis. They are broadly defined as follows:

- **Level 1 Funding (Level 1) –** Funding needed to **provide the minimum** LOS that meets both community-wide expectations and **existing** regulatory requirements over the 20-year IMP planning period.
- **Level 2 Funding (Level 2) –** Funding needed to **exceed the minimum** LOS that meets community-wide expectations and **more proactively** meets existing regulatory requirements over the 20-year IMP planning period.
- **Level 3 Funding (Level 3) –** Funding needed to **address all** forecasted infrastructure needs and proactively meet **both** existing and forecasted regulatory requirements over the 20-year IMP planning period.

The estimates include potential capital costs, operation and maintenance costs, and costs associated with necessary planning or data collection activities needed over the IMP planning period. The resulting total and annual spending differences between each funding level presented above are the product of assumptions related to total project implementation cost, project scheduling, and the timing of known regulatory drivers. Because the 2015 voter-approved rate increase is scheduled to continue through 2020, the City cannot plan to dedicate additional funds to stormwater projects until at least 2021. Therefore, the IMP assumes that no new funding would be dedicated to any of the three levels described above until 2021, assuming future rate increases are approved by voters. Further, it is important to note that annual expenditures for each category outlined below should be considered “average annual” costs over the planning period, as actual annual costs may vary to accommodate future stormwater rate calculations.

Funding level estimates were developed for six major project categories focused on improving infrastructure and water quality. These categories are:

- Stormwater planning,
- System assessment and cleaning,
- System renewal,
- Flood control,
- Stream erosion,
- Runoff treatment to improve water quality, and
- Stormwater management program.

Brief descriptions of these project categories and the assumptions used to develop funding level estimates are described in the sections that follow. Detailed costs forecasts for each funding level are presented in **Attachment A**.

3.1 Stormwater Planning and Program Support

It has been approximately 20 years since comprehensive stormwater management, planning, and modeling tools have been evaluated for the City[2]. Changing development patterns and densities, increasing population growth, expanding City boundaries, and evolving regulatory requirements over that time have significantly changed the conditions and assumptions on which those plans were based. As a result, the City has been operating the Stormwater Utility without the benefit of a functional stormwater master plan or conveyance system model for some time. These tools, as well as improved data management processes, should be developed to enhance project planning, prioritization, and identification of improvement locations to more fully meet conveyance system assessment goals. Results of these efforts will be used to refine funding needs and identify a long term improvement plan to address the conveyance issues present within the system.

As discussed in TM4, improving the quality of stormwater system data and GIS mapping information is a priority for the City. The most significant needs at this time include improving the consistency of existing data management and storage. As the stormwater program grows and additional asset information such as cleaning records, maintenance activities, and overall condition is collected, more robust data management tools will be needed to support necessary planning and analysis efforts. These tools will help the City efficiently maintain existing stormwater assets and proactively address problematic areas or conditions. They will also help facilitate coordination with Boone County and the University of Missouri.

Estimated costs for data management (program support), master planning, and modeling were developed based on similar efforts in other Midwest communities. These estimates were used as the basis for estimating funding needs for the first steps in evaluating the conveyance system. Planned resources may be needed or may need to be reallocated to manage future program activities based on the results of the master planning and modeling efforts. For initial planning purposes, the funding scenarios assume that external consultants will be retained to assist with program support. As the program develops over time, these estimates can be refined to incorporate the appropriate mix of internal and external resources.

Assumptions used to develop funding scenarios according to the three IMP levels included in this evaluation are as follows:

- **Level 1 – Stormwater Master Planning and Low Level Program Support**
    - $650,000 total over five years to develop master plan and modeling.
    - On average, $50,000 annually throughout planning period for program and data management support.

[2] Black and Veatch. 1983. Stormwater Management Plan for Columbia, Missouri. Kansas City, Missouri.
Burns and McDonnell. 1996. Phase 1 Stormwater Management Plan. Kansas City, Missouri.
Burns and McDonnell. 1998. Phase 2 Stormwater Management Plan. Kansas City, Missouri.

- **Level 2 – Stormwater Master Planning and Medium Level Program Support**
  - $650,000 total over five years to develop master plan and modeling.
  - On average, $100,000 annually for program and data management support.
- **Level 3 – Stormwater Master Planning and High Level Program Support**
  - $650,000 total over five years to develop master plan and modeling.
  - On average, $150,000 annually for program and data management support.

3.2 System Condition Assessment and Cleaning Program

To help meet the goal of assessing and maintaining the stormwater conveyance system, a more systematic approach is recommended to decrease unanticipated costs through system evaluation and maintenance. Assumptions used to develop system condition assessment and cleaning funding scenarios according to the three IMP funding levels included in this evaluation are outlined below. These estimates are based on existing data and information and should be refined as stormwater planning activities outlined in Section 3.1 are completed.

- **Level 1 – Establish the Condition Assessment and Dedicated Cleaning Program**
  - Add 1 dedicated CCTV truck to be replaced every 10 years beginning in 2021.
  - Add two new CCTV staff.
- **Level 2 – Establish the Programs and Assess the CMPs within Three Years**
  - Add 1 dedicated CCTV truck to be replaced every 10 years beginning in 2021.
  - Add two new CCTV staff.
  - Beginning in 2021, $250,000 over three years to enhance the assessment program by using a subcontractor to assess half of the CMP (approximately 30 miles) within 3 years
  - 1 additional staff engineer to oversee the enhanced assessment.
- **Level 3 – Same as Level 2**

3.3 System Renewal

To meet the goal of maintaining the stormwater conveyance system, a more proactive approach is recommended to decrease emergency repairs and unanticipated costs. This includes additional resources to repair and rehabilitate the system and additional staff to provide necessary support for the increased system renewal efforts. The funding levels for system renewal were determined by using the current GIS database which includes system ages for 70% of the pipes and structures. Ages for the remaining 30% of the system were assigned as described in TM4 Ages were used to determine the current backlog based upon the assumed PEL. According to the analysis, CMP is the most common pipe used in the system and 33% of the CMP is currently beyond its PEL. Failing CMP is the most significant threat to public health, safety, and water quality.

Costs were calculated for pipe lining or renewal. Lining costs were calculated for non-concrete pipes with diameters of 8 to 48 inches. Renewal costs were also calculated for the various structures present in the system, including area inlets, curb inlets, inlet lids, junction structures, and end structures. Costs also included surface restoration (non-lined), contingency, and engineering. Estimates are based on existing information and should be refined as stormwater planning and assessment activities outlined in Sections 3.1 and 3.2 are completed. The general assumptions used to develop system renewal funding scenarios according to the three IMP funding levels included in this evaluation are included below.

- **Level 1 – Repair or Replace 50% of the CMP and Replace 50% of Structures that will be beyond PEL during the 20-Year Planning Period**
  Within the 20-year planning period, approximately 38 miles of CMP and 13,300 structures will age beyond their PEL. Level 1 assumes that 50% of the CMP (approximately 19 miles) and 50% of the structures (approximately 6,660) will be repaired or replaced over the 20-year planning period.
  - Approximately $800,000 annually to rehabilitate approximately 19 miles of CMP (line 75% and replace 25%).
  - Approximately $2.6 million annually to replace 50% of the structures (6,600 structures).
  - Add three operators, one staff engineer, one engineering technician, and one inspector to help manage and execute the program. Costs for these additional staff were not considered, as they are already accounted for in the Utility's existing budget projections based on the planned rate increases through 2020.

- **Level 2 – Repair or Replace 100% of the CMP and Replace 50% of Structures that will be beyond PEL during the 20-Year Planning Period**
  Within the 20-year planning period, approximately 38 miles of CMP and 13,300 structures will age beyond their PEL. Level 2 assumes that 100% of the CMP (approximately 38 miles) and 50% of the structures (approximately 6,660) will be repaired or replaced.
  - Approximately $1.6 million annually to rehabilitate approximately 38 miles of CMP (line 75% and replace 25%).
  - Approximately $2.6 million annually to replace 50% of the structures (6,600 structures).
  - Add three operators, one staff engineer, one engineering technician, and one inspector to help manage and execute the program. Costs for these additional staff were not considered, as they are already accounted for in the Utility's existing budget projections based on the planned rate increases through 2020.

- **Level 3 – Repair or Replace 100% of the System that will be beyond PEL within First 10 Years of the IMP Planning Period**
  Within the 20-year planning period, approximately 63 miles of pipe (of various materials) and 13,300 structures will age beyond their PEL. Replacing all of these assets is cost prohibitive. Therefore, Level 3 only includes costs for pipes and structures that will age beyond their PEL during the first 10 years, but assumes that they will be repaired or replaced over a 20-year period.

  Approximately 35 of miles of pipe will age beyond their PEL during the first 10 years of the planning period. A significant portion of this 35 miles is CMP, but includes other pipe materials as well. Level 3 assumes that 100% of the 35 miles will be repaired or replaced over a 20-year period.

Approximately 9,400 of the 13,300 structures will age beyond their PEL duirng the first 10 years of the planning period. Level 3 assumes that 100% of the 9,400 structures will be replaced over a 20-year period.

  - Approximately $3.9 million annually to rehabilitate approximately 35 miles of all pipe types (line 75% and replace 25%).
  - Approximately $3.4 million annually to replace 100% of the structures (9,400 structures).
  - Add three operators, one staff engineer, one engineering technician, and one inspector to help manage and execute the program. Costs for these additional staff were not considered, as they are already accounted for in the Utility's existing budget projections based on the planned rate increases through 2020.

3.4 Flood Reduction

The City has identified approximately $23 million of immediate flood reduction needs. As the City works to develop stormwater master planning efforts over time, new flood reduction projects will be identified and existing projects and estimates may be refined. Assumptions used to develop IMP cost estimates are as follows:

- **Level 1 – Low Level Investment in Flood Reduction**
  - After 2020, approximately $1.4 million annually ($23 million total) to complete identified projects.
  - One engineer, one inspector, and one technician to help manage and execute the program.
  - Two field trucks to be replaced every 10 years.
- **Level 2 – Medium Level Investment in Flood Reduction**
  - After 2020, approximately $1.4 million annually ($23 million total) to complete identified projects.
  - After 2020, approximately $440,000 annually ($7 million total) to complete unidentfied projects.
  - One engineer, one inspector, and one technician to help manage and execute the program.
  - Two field trucks to be replaced every 10 years.
- **Level 3 – High Level Investment in Flood Reduction**
  - After 2020, approximately $1.4 million annually ($23 million total) to complete identified projects.
  - After 2020, approximately $875,000 annually ($14 million total) to complete unidentfied projects.
  - One engineer, one inspector, and one technician to help manage and execute the program.
  - Two field trucks to be replaced every 10 years.

3.5 Stream Erosion

Erosion contributes to water quality and habitat degradation issues in stream channels. Erosion also causes private and public property damage, impacts infrastructure such as roads, sanitary sewers and other utilities, and can exacerbate downstream flooding concerns. In addition, City staff has indicated that there are growing expectations from the community that the City should be responsible for addressing these problems.

Stream erosion restoration cost estimates were developed from complaints in the database provided by the City and engineering judgment. Only the complaints related to either "yard" or "severe" erosion in the database were considered. For purposes of this analysis, it was assumed that complaints located within 250 feet of high resolution (1:24,000) USGS national hydrography dataset flowlines were related to stream erosion.

Each complaint was assumed to impact approximately 200 feet of streambank based on expected lot sizes. Past project experience indicated that a cost of $300 per linear foot of stream restoration was an appropriate estimate. Therefore, each complaint was associated with a cost of $60,000 for restoration. The cost for restoration was developed based on the number of complaints grouped by watershed.

The funding scenarios outlined below were structured to address watersheds with the most critical erosion issues first. Assumptions used to develop the scenarios according to the three IMP funding levels included in this evaluation were as follows:

- **Level 1 – Address Critical Erosion Areas**
  - Approximately $173,000 annually after 2020 to address stream erosion in watersheds with a high frequency of erosion complaints (>5 complaints per mile). These watersheds include the Mill Creek and County House Branch watersheds.
- **Level 2 – Address Erosion in the Hinkson Creek Watershed**
  - Approximately $485,000 annually after 2020 to address the Level 1 watersheds, remaining Hinkson Creek mainstem, and Hinkson Creek tributary watersheds.
  - Add one engineer to coordinate and manage projects, one inspector, and one field truck to be replaced every 10 years.
- **Level 3 – Address Erosion in all Watersheds**
  - Approximately $700,000 annually after 2020 to address all watershed areas in the City.
  - Add one engineer to coordinate and manage projects, one inspector, and one field truck to be replaced every 10 years.

3.6 Runoff Treatment for Water Quality

Similar to erosion, stormwater runoff impacts downstream water quality. Pollutants such as sediment, debris, phosphorus, nitrogen, oil and grease, pesticides, and pathogens can be carried by stormwater into local waterways and impact aquatic health, recreation, and aesthetics. Runoff treatment with structural BMPs will reduce the volume of stormwater runoff, thereby reducing flooding, and will retain pollutants, including sediment, to prevent transport to local waterways.

Runoff treatment alternatives were focused on addressing stormwater runoff from impervious areas only within the road right-of-way (ROW) owned by the City. The City has approximately 16 square miles of impervious surface, including 5 square miles within the road ROW. The analysis assumed that 100% of the impervious area within the City's ROW would be treated through structural BMPs. Based on discussions with the City, the two BMPs selected for implementation in the runoff treatment analysis were bioretention basins and permeable pavers. It is important to note that this combination was chosen to simplify the analyses. Prior to implementation, a site-specific evaluation would be needed to identify the appropriate suite of BMPs that would be appropriate for each project.

Costs for runoff treatment were based on unit cost information developed for the EPA National Stormwater Calculator. A regionalization factor for St. Louis was applied using the Bureau of Labor Statistics Consumer Price Index and Producer Price Index. Cost estimates do not include engineering or other soft costs associated with BMP implementation. Assumptions used to develop BMP costs used for the evaluation include the following:

- BMP is sited on an existing development or is a substantial retrofit of existing infrastructure that is likely to have moderate to very constrained space;
- Areas for outflow and overflow discharge are likely constrained and may require significant grading or pipe infrastructure for safe discharge;
- Placement location of the BMP has difficult access for equipment and material delivery;
- Placement location is controlled by steep slopes (i.e. greater than 7%); or
- Soil infiltration rates of the existing subgrade beneath the BMP are representative of Hydrologic Soil Group C and D soils.

For planning purposes, implementation was assumed to be 50% bioretention and 50% permeable pavers based on discussions with City staff. The costs were estimated and applied on a watershed basis. Assumptions used to develop runoff treatment scenarios according to the three IMP funding levels included in this evaluation are as follows:

- **Level 1 – Re-evaluate Existing Redevelopment Ordinance and Opportunistic BMP Implementation**
  - No additional costs.
- **Level 2– Address Runoff in Tributary Watersheds of Hinkson Creek**
  - Approximately $2.7 million annually after 2020 to treat runoff in all Hinkson Creek tributary watersheds. This estimate does not include treating runoff in the mainstem Hinkson Creek watershed. Addressing runoff quality in tributary watersheds is also expected to benefit the mainstem of Hinkson Creek.
  - Add one engineer to coordinate and manage projects.
- **Level 3 – Address Runoff in All Watersheds**
  - Approximately $7.5 million annually after 2020 to treat runoff in all watershed areas in the City.
  - Add one engineer and one technician to coordinate and manage projects.
  - One field truck to be replaced every 10 years.

3.7 Stormwater Management Program

Enhancing the City's stormwater management program, specifically Minimum Control Measures (MCMs) #1, #3, and #4, to address water quality issues would consist of expanding the education and outreach, illicit discharge detection elimination (IDDE), and construction site stormwater runoff control programs, respectively. In conjunction with the IDDE program, streams in the City could be inspected for erosion problems to better identify and characterize the extent of stream erosion in the City.

MCM #1: Public Education and Outreach

Current funding (excluding staffing costs) for the City's education and outreach program is $27,000 per year. In general, City staff has developed and is implementing a program that provides a wide array of education and outreach opportunities with limited funds. The US EPA often directs other communities to contact the City staff to learn about ways to cost-effectively develop a successful stormwater education and outreach program.

City staff places a heavy emphasis on "people pollution," meaning individual behaviors are a large source of stormwater pollution within the City. Significant amounts of litter following sporting events and residential fertilizer application are provided as examples of "people pollution." To provide effective education and outreach opportunities to address and positively change these individual behaviors, the City staff needs to have a significant amount of close interaction with the residents of the City. These interactions include providing education and outreach at schools, community and religious organizations, and public events. However, the City's ability to deliver education and outreach at more of these settings is limited by current staffing levels. As such, the City has identified that the addition of up to three part-time employees, such as university students, would allow for increased education and outreach delivery to City residents.

MCM #3: Illicit Discharge Detection and Elimination Program

There are approximately 150 stream miles in the City. Costs for implementing an enhanced IDDE and stream erosion assessment program were developed by estimating the amount of time necessary to conduct stream walks and associated administrative tracking and coordination. Since extended dry periods are necessary for IDDE inspections, the number of available dry days per year for inspection was calculated based on the average number of days measured flows in Hinkson Creek (at USGS gage station 06910230) were below the long-term median flow value since 2008. Additional days per year for other IDDE tasks include the following:

1) 10 days: field testing and tracing detected illicit discharges;
2) 5 days: removing the source of discharge and post-monitoring;
3) 20 days: development of a public IDDE reporting program; and
4) 20 days: IDDE public outreach and education.

Based on these data, one full-time employee would be needed to conduct one assessment of the 150-mile system during every 5-year MS4 permit cycle.

MCM #4: Construction Site Stormwater Runoff Control

Expanding the construction site stormwater runoff control program would consist of adding dedicated full-time equivalent (FTE) employees to perform inspections. The current construction inspection program includes building and site inspectors from the City's Community Development Department performing stormwater inspections weekly at each construction site. The weekly inspection frequency is required by existing permits but is intended to apply only to the permit holder, not to the City who should be acting in an oversight role. It is generally recommended that the City perform less frequent, but more intense, audits of construction sites. This approach would require that the City have dedicated staff trained to conduct audits, rather than building inspectors. The required number of FTEs was calculated based on 2016 construction inspection data provided by the City, and included the following assumptions:

1) 3 hours/inspection: Travel time and site visit;
2) 1 hour/inspection: In-office reporting;
3) 3 inspections/month: Notice of Violation (NOV) discovery; and
4) 4 hours/NOV: In-office reporting and follow-up.

Stormwater Management Program Funding Scenarios

Funding scenarios targeted at enhancing MCMs #1, #3, and #4 described above will improve the City's ability to conduct outreach, enhance existing IDDE capabilities, and make construction site stormwater runoff control programs more effective. Assumptions used to develop program funding scenarios according to the three IMP levels included in this evaluation are as follows:

- **Level 1 – Enhance Outreach and Education, Implement Stream Walks, and Conduct Monthly Erosion Control Inspections**
  - Additional $73,000 annually after 2020 to conduct additional outreach and education (MCM #1).
  - One technician to perform stream walks (1/permit cycle) and stream erosion inspections (MCM #3).
  - Three technicians to perform monthly construction site erosion control inspections (MCM #4).
  - Four new trucks to be replaced every 10 years. It is assumed that these trucks will also be used to support work conducted under the Stream Erosion and Runoff Treatment project categories.
- **Level 2 – Enhance Outreach and Education, Implement Enhanced Stream Walks, and Conduct Monthly Erosion Control Inspections**
  - Additional $73,000 annually after 2020 to conduct additional outreach and education (MCM #1).
  - 1 Field Technician to perform stream walks (1/permit cycle) and stream erosion inspections (MCM #3).
  - 4 Field Technicians to perform monthly erosion control inspections (MCM #4).

- Five new trucks to be replaced every 10 years. It is assumed that these trucks will also be used to support work conducted under the Stream Erosion and Runoff Treatment project categories.

- **Level 3 – Enhance Outreach and Education, Implement Enhanced Stream Walks, and Conduct Bi-Monthly Erosion Control Inspections**
    - Additional $73,000 annually after 2020 to conduct additional outreach and education (MCM #1).
    - 1 Field Technician to perform stream walks (1/permit cycle) and stream erosion inspections (MCM #3).
    - 5 Field Technicians to perform bi-monthly erosion control inspections (MCM #4).
    - Six new trucks to be replaced every 10 years. It is assumed that these trucks will also be used to support work conducted under the Stream Erosion and Runoff Treatment project categories.

Section 4. Summary

HDR and Geosyntec worked with the City to review existing stormwater system goals and develop alternatives to address system and program needs identified in TM4. Most importantly, TM4 highlighted the fact that the current level of asset management investment is not sufficient to address existing renewal or assessment needs. Continued underfunding and deferment of system replacement, renewal, and assessment activities will reduce system function and reliability and contribute to public health, safety, and water quality issues.

In 2008, the City sponsored a stakeholder process to identify and prioritize program goals (CH2MHill 2008). As part of the alternative development process for the IMP, HDR and Geosyntec reviewed these goals with City staff and confirmed that they still generally reflect the overall goals and objectives of the current Utility. However, the group decided that the original six goals could logically be re-categorized and reduced to the following four goals which still capture the Utility's priorities:

1. Provide Public Safety
2. Improve Environmental Integrity
3. Renew and Maintain the Stormwater Conveyance System
4. Adequately Fund and Staff the Stormwater Utility

Developing and implementing the stormwater program to achieve these four goals will help ensure that public health protections are maintained, LOS goals are achieved, and environmental protections are economically sensible. Appropriate KPIs to help the City track performance and achievement of these goals will be developed over time as the IMP is implemented and more data become available.

Potential capital and programmatic alternatives and planning level costs were identified to characterize the expected additional level of investment required to address stormwater system needs, anticipated regulatory drivers, and City goals over the 20-year IMP planning period. Cost estimates include potential additional capital, operation and maintenance, and necessary planning or data collection costs. Estimates were developed for three potential funding level scenarios and six project categories. The three funding levels represent increasingly proactive investments that the City could pursue to make infrastructure upgrades and water quality improvements through the IMP.

Results of the alternatives evaluation indicate that between \$93 million and \$306 million of **additional** investment will be needed to address stormwater system needs over the IMP planning period (Table 1). In subsequent analyses, these cost estimates will be combined with estimates for the wastewater treatment and collection system and evaluated to identify the level of investment that appropriately balances overall costs with anticipated community benefits. These subsequent evaluations will also consider impacts on future residential utility bills and community-wide affordability.

Table 1.Summary of Stormwater System Capital and Programmatic Costs, in 2017 Dollars.

Project Categories	20-Year Funding Scenario		
	Level 1	**Level 2**	**Level 3**
Stormwater Planning	$1,450,000	$2,250,000	$3,050,000
System Assessment and Cleaning	$2,080,000	$2,330,000	$2,330,000
System Renewal	$54,241,000	$67,477,000	$116,379,000
Flood Reduction	$26,570,000	$33,620,000	$40,620,000
Stream Erosion	$2,760,000	$10,270,000	$13,810,000
Runoff Treatment for Water Quality	$0	$44,145,00	$122,396,000
Stormwater Management Program	$5,544,000	$6,634,000	$7,724,000
Total Additional Cost	**$92,645,00**	**$166,726,000**	**$306,309,000**
Additional Staff*	**Engineer (1) Technician** (8)**	**Engineer (4) Technician (10)**	**Engineer (4) Technician (12)**
Additional Equipment	**CCTV Truck (1) Field Truck (6)**	**CCTV Truck (1) Field Truck (8)**	**CCTV Truck (1) Field Truck (9)**

*Additional staff estimates include only those staff for which the Utility would incur additional costs. The estimates do not include the seven existing staff members or eight additional staff members that the Utility plans to add over the next four years. These staffing estimates (and associated costs) were developed for initial IMP planning purposes. Future staffing levels, as well as specific positions, should be reevaluated as the IMP progresses over time.
**In this table, the term “technician” refers to all operators, inspectors, and technicians.

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Attachments

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Attachment A. Detailed Cost Forecasts

Table A.1. Level 1 Stormwater System Capital and Programmatic Cost Forecast, in 2017 Dollars. Estimates include potential additional capital, operation and maintenance, and planning costs over the IMP planning period. Because the 2015 voter-approved rate increase is scheduled to continue through 2020, the IMP assumes that no additional funding would be dedicated to any of the three levels described above until 2021.

Columbia Stormwater System
Capital and Programmatic Cost Estimates - Level 1 Service

Project Category	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Stormwater Planning	$ -	$ -	$ -	$ -	$ 180,000	$ 180,000	$ 180,000	$ 180,000	$ 180,000	$ 50,000
Condition Assessment and Cleaning	$ -	$ -	$ -	$ -	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000
System Renewal Program	$ -	$ -	$ -	$ -	$ 3,390,051	$ 3,390,051	$ 3,390,051	$ 3,390,051	$ 3,390,051	$ 3,390,051
Flood Reduction	$ -	$ -	$ -	$ -	$ 1,657,500	$ 1,657,500	$ 1,657,500	$ 1,657,500	$ 1,657,500	$ 1,657,500
Stream Erosion	$ -	$ -	$ -	$ -	$ 172,500	$ 172,500	$ 172,500	$ 172,500	$ 172,500	$ 172,500
Runoff Treatment	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Stormwater Management Program	$ -	$ -	$ -	$ -	$ 434,000	$ 334,000	$ 334,000	$ 334,000	$ 334,000	$ 334,000
Annual Total	**$ -**	**$ -**	**$ -**	**$ -**	**$ 5,964,051**	**$ 5,864,051**	**$ 5,864,051**	**$ 5,864,051**	**$ 5,864,051**	**$ 5,734,051**
Cumulative Total	**$ -**	**$ -**	**$ -**	**$ -**	**$ 5,964,051**	**$ 11,828,101**	**$ 17,692,152**	**$ 23,556,202**	**$ 29,420,253**	**$ 35,154,303**

Columbia Stormwater System
Capital and Programmatic Cost Estimates - Level 1 Service

Project Category	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036
Stormwater Planning	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000
Condition Assessment and Cleaning	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000
System Renewal Program	$ 3,390,051	$ 3,390,051	$ 3,390,051	$ 3,390,051	$ 3,390,051	$ 3,390,051	$ 3,390,051	$ 3,390,051	$ 3,390,051	$ 3,390,051
Flood Reduction	$ 1,657,500	$ 1,707,500	$ 1,657,500	$ 1,657,500	$ 1,657,500	$ 1,657,500	$ 1,657,500	$ 1,657,500	$ 1,657,500	$ 1,657,500
Stream Erosion	$ 172,500	$ 172,500	$ 172,500	$ 172,500	$ 172,500	$ 172,500	$ 172,500	$ 172,500	$ 172,500	$ 172,500
Runoff Treatment	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Stormwater Management Program	$ 334,000	$ 334,000	$ 334,000	$ 334,000	$ 434,000	$ 334,000	$ 334,000	$ 334,000	$ 334,000	$ 334,000
Annual Total	**$ 5,734,051**	**$ 5,784,051**	**$ 5,734,051**	**$ 5,734,051**	**$ 5,834,051**	**$ 5,734,051**	**$ 5,734,051**	**$ 5,734,051**	**$ 5,734,051**	**$ 5,734,051**
Cumulative Total	**$ 40,888,354**	**$ 46,672,404**	**$ 52,406,455**	**$ 58,140,505**	**$ 63,974,556**	**$ 69,708,606**	**$ 75,442,657**	**$ 81,176,707**	**$ 86,910,758**	**$ 92,644,808**

Table A.2. Level 2 Stormwater System Capital and Programmatic Cost Forecast, in 2017 Dollars. Estimates include potential additional capital, operation and maintenance, and planning costs over the IMP planning period. Because the 2015 voter-approved rate increase is scheduled to continue through 2020, the IMP assumes that no additional funding would be dedicated to any of the three levels described above until 2021.

Columbia Stormwater System Capital and Programmatic Cost Estimates - Level 2 Service										
Project Category	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**
Stormwater Planning	$ -	$ -	$ -	$ -	$ 230,000	$ 230,000	$ 230,000	$ 230,000	$ 230,000	$ 100,000
Condition Assessment and Cleaning	$ -	$ -	$ -	$ -	$ 213,468	$ 213,468	$ 213,468	$ 130,000	$ 130,000	$ 130,000
System Renewal Program	$ -	$ -	$ -	$ -	$ 4,217,341	$ 4,217,341	$ 4,217,341	$ 4,217,341	$ 4,217,341	$ 4,217,341
Flood Reduction	$ -	$ -	$ -	$ -	$ 2,145,000	$ 2,095,000	$ 2,095,000	$ 2,095,000	$ 2,095,000	$ 2,095,000
Stream Erosion	$ -	$ -	$ -	$ -	$ 663,750	$ 638,750	$ 638,750	$ 638,750	$ 638,750	$ 638,750
Runoff Treatment	$ -	$ -	$ -	$ -	$ 2,759,081	$ 2,759,081	$ 2,759,081	$ 2,759,081	$ 2,759,081	$ 2,759,081
Stormwater Management Program	$ -	$ -	$ -	$ -	$ 524,000	$ 399,000	$ 399,000	$ 399,000	$ 399,000	$ 399,000
Annual Total	**$ -**	**$ -**	**$ -**	**$ -**	**$ 10,752,639**	**$ 10,552,639**	**$ 10,552,639**	**$ 10,469,171**	**$ 10,469,171**	**$ 10,339,171**
Cumulative Total	**$ -**	**$ -**	**$ -**	**$ -**	**$ 10,752,639**	**$ 21,305,279**	**$ 31,857,918**	**$ 42,327,089**	**$ 52,796,261**	**$ 63,135,432**

Columbia Stormwater System Capital and Programmatic Cost Estimates - Level 2 Service										
Project Category	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**
Stormwater Planning	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000
Condition Assessment and Cleaning	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000
System Renewal Program	$ 4,217,341	$ 4,217,341	$ 4,217,341	$ 4,217,341	$ 4,217,341	$ 4,217,341	$ 4,217,341	$ 4,217,341	$ 4,217,341	$ 4,217,341
Flood Reduction	$ 2,095,000	$ 2,095,000	$ 2,095,000	$ 2,095,000	$ 2,145,000	$ 2,095,000	$ 2,095,000	$ 2,095,000	$ 2,095,000	$ 2,095,000
Stream Erosion	$ 638,750	$ 638,750	$ 638,750	$ 638,750	$ 663,750	$ 638,750	$ 638,750	$ 638,750	$ 638,750	$ 638,750
Runoff Treatment	$ 2,759,081	$ 2,759,081	$ 2,759,081	$ 2,759,081	$ 2,759,081	$ 2,759,081	$ 2,759,081	$ 2,759,081	$ 2,759,081	$ 2,759,081
Stormwater Management Program	$ 399,000	$ 399,000	$ 399,000	$ 399,000	$ 524,000	$ 399,000	$ 399,000	$ 399,000	$ 399,000	$ 399,000
Annual Total	**$ 10,339,171**	**$ 10,339,171**	**$ 10,339,171**	**$ 10,339,171**	**$ 10,539,171**	**$ 10,339,171**	**$ 10,339,171**	**$ 10,339,171**	**$ 10,339,171**	**$ 10,339,171**
Cumulative Total	**$ 73,474,603**	**$ 83,813,775**	**$ 94,152,946**	**$ 104,492,117**	**$ 115,031,289**	**$ 125,370,460**	**$ 135,709,631**	**$ 146,048,803**	**$ 156,387,974**	**$ 166,727,145**

Table A.3. Level 3 Stormwater System Capital and Programmatic Cost Forecast, in 2017 Dollars. Estimates include potential additional capital, operation and maintenance, and planning costs over the IMP planning period. Because the 2015 voter-approved rate increase is scheduled to continue through 2020, the IMP assumes that no additional funding would be dedicated to any of the three levels described above until 2021.

Columbia Stormwater System
Capital and Programmatic Cost Estimates - Level 2 Service

Project Category	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Stormwater Planning	$ -	$ -	$ -	$ -	$ 280,000	$ 280,000	$ 280,000	$ 280,000	$ 280,000	$ 150,000
Condition Assessment and Cleaning	$ -	$ -	$ -	$ -	$ 213,468	$ 213,468	$ 213,468	$ 130,000	$ 130,000	$ 130,000
System Renewal Program	$ -	$ -	$ -	$ -	$ 7,273,668	$ 7,273,668	$ 7,273,668	$ 7,273,668	$ 7,273,668	$ 7,273,668
Flood Reduction	$ -	$ -	$ -	$ -	$ 2,582,500	$ 2,532,500	$ 2,532,500	$ 2,532,500	$ 2,532,500	$ 2,532,500
Stream Erosion	$ -	$ -	$ -	$ -	$ 885,000	$ 860,000	$ 860,000	$ 860,000	$ 860,000	$ 860,000
Runoff Treatment	$ -	$ -	$ -	$ -	$ 7,649,774	$ 7,649,774	$ 7,649,774	$ 7,649,774	$ 7,649,774	$ 7,649,774
Stormwater Management Program	$ -	$ -	$ -	$ -	$ 614,000	$ 464,000	$ 464,000	$ 464,000	$ 464,000	$ 464,000
Annual Total	**$ -**	**$ -**	**$ -**	**$ -**	**$ 19,498,410**	**$ 19,273,410**	**$ 19,273,410**	**$ 19,189,942**	**$ 19,189,942**	**$ 19,059,942**
Cumulative Total	**$ -**	**$ -**	**$ -**	**$ -**	**$ 19,498,410**	**$ 38,771,820**	**$ 58,045,229**	**$ 77,235,171**	**$ 96,425,113**	**$ 115,485,055**

Columbia Stormwater System
Capital and Programmatic Cost Estimates - Level 2 Service

Project Category	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036
Stormwater Planning	$ 150,000	$ 150,000	$ 150,000	$ 150,000	$ 150,000	$ 150,000	$ 150,000	$ 150,000	$ 150,000	$ 150,000
Condition Assessment and Cleaning	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000
System Renewal Program	$ 7,273,668	$ 7,273,668	$ 7,273,668	$ 7,273,668	$ 7,273,668	$ 7,273,668	$ 7,273,668	$ 7,273,668	$ 7,273,668	$ 7,273,668
Flood Reduction	$ 2,532,500	$ 2,532,500	$ 2,532,500	$ 2,532,500	$ 2,582,500	$ 2,532,500	$ 2,532,500	$ 2,532,500	$ 2,532,500	$ 2,532,500
Stream Erosion	$ 860,000	$ 860,000	$ 860,000	$ 860,000	$ 885,000	$ 860,000	$ 860,000	$ 860,000	$ 860,000	$ 860,000
Runoff Treatment	$ 7,649,774	$ 7,649,774	$ 7,649,774	$ 7,649,774	$ 7,649,774	$ 7,649,774	$ 7,649,774	$ 7,649,774	$ 7,649,774	$ 7,649,774
Stormwater Management Program	$ 464,000	$ 464,000	$ 464,000	$ 464,000	$ 614,000	$ 464,000	$ 464,000	$ 464,000	$ 464,000	$ 464,000
Annual Total	**$ 19,059,942**	**$ 19,059,942**	**$ 19,059,942**	**$ 19,059,942**	**$ 19,284,942**	**$ 19,059,942**	**$ 19,059,942**	**$ 19,059,942**	**$ 19,059,942**	**$ 19,059,942**
Cumulative Total	**$ 134,544,997**	**$ 153,604,939**	**$ 172,664,880**	**$ 191,724,822**	**$ 211,009,764**	**$ 230,069,706**	**$ 249,129,648**	**$ 268,189,590**	**$ 287,249,531**	**$ 306,309,473**

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Columbia Wastewater and Stormwater IMP

Attachment N

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Our Columbia Waters
Integrated Management Plan
Wastewater & Stormwater

Technical Memorandum 9
Alternatives Decision Analysis Process

Columbia Wastewater and Stormwater Integrated Management Plan

Columbia, Missouri
January 5, 2018

HDR

Geosyntec consultants
Shockey Consulting Services, llc
TREKK DESIGN GROUP, LLC

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Section 1. Introduction and Objectives

The City of Columbia, Missouri (City) is working to develop an Integrated Management Plan (IMP) for the City's Sewer and Storm Water Utilities. The goal of the IMP is to develop an adaptable and affordable long-term plan that addresses the City's wastewater and stormwater management needs and meets Clean Water Act requirements. The IMP will be developed based on guidance presented in US Environmental Protection Agency's (EPA) *Integrated Municipal Stormwater and Wastewater Planning Approach Framework*[1].

Early in the IMP process, the City and their project team worked to evaluate the City's environmental resources and infrastructure assets to better define the existing condition, performance, and needs of its systems. These needs assessments were useful in guiding initial prioritization of potential wastewater and stormwater improvements. Priorities were further refined during a series of community outreach meetings. Information developed from these activities formed the basis for identifying potential capital and programmatic alternatives that should be evaluated as part of the IMP. Outcomes from these efforts have been documented in the following technical memoranda:

- Technical Memorandum 5 – Wastewater Collection System Alternatives
- Technical Memorandum 6 – Wastewater Treatment System Alternatives
- Technical Memorandum 7 – Stormwater System Alternatives
- Technical Memorandum 8 – Community Outreach Results

The purpose of this memorandum is to document the approach and methods that HDR Engineering, Inc. (HDR) led consulting team and the City (hereinafter, the "project team") used to select the wastewater and stormwater programmatic and project alternatives that should be implemented to achieve objectives of the IMP. As discussed herein, the project team used a multiple criteria decision analysis (MCDA) tool to quantify anticipated benefits associated with implementing the various stormwater and wastewater alternatives identified and described in the Technical Memoranda listed above. These benefit scores were then evaluated with respect to projected costs to identify an optimized suite of stormwater and wastewater projects that provides the greatest benefit to the community per dollar invested. Pending an evaluation of community affordability (see Technical Memorandum 10), the resulting suite of optimized projects will reflect the wastewater and stormwater alternatives that the City will potentially implement under the IMP going forward. More details regarding the MCDA analysis are presented in the sections that follow.

[1] Stoner, N. and C. Giles. 2012. Integrated Municipal Stormwater and Wastewater Planning Approach Framework. June 5, 2012. Washington D.C.

Section 2. Alternatives Identification Review

The project team developed a series of alternatives and associated implementation costs to address wastewater treatment, wastewater collection, and stormwater management needs identified during early phases of IMP development. Results of these activities are summarized below. For a more detailed description of the alternatives identification process, please refer to Technical Memoranda 5, 6, and 7.

The goal of the alternatives identification process was to develop planning level estimates to characterize the expected additional level of investment required to address system needs, anticipated regulatory drivers, and City goals over the next 20 years (the IMP planning period). To facilitate this evaluation, wastewater and stormwater alternatives were grouped and analyzed by project category (Table 1).

Table 1. Project Categories Evaluated as Part of the IMP Alternatives Identification Process.

Wastewater Treatment	Wastewater Collection	Stormwater Management
• Wet Weather Improvements • Expanded Nitrification • Biological Nutrient Removal • Chemical Disinfection • Constructed Wetlands Improvements • Biosolids Rehabilitation • Biosolids Capacity Improvements	• Wet Weather Program Planning • Asset Management • System Renewal • System Capacity • Reducing Building Backups • Private Common Collector Elimination • System Expansion • Cleaning Program • Pump Station Repair • Annual Sewer Improvements	• Stormwater Planning • System Assessment and Cleaning • System Renewal • Flood Control • Stream Erosion • Runoff Treatment to Improve Water Quality • Stormwater Management Program

Cost estimates were developed for each project category to quantify the investments and resources needed ***in addition to*** those already managed by the Sewer and Stormwater Utilities. The cost estimates include potential additional capital costs, operation and maintenance costs, and costs associated with necessary planning or data collection activities needed over the 20-year IMP planning period. The three potential funding scenarios used to guide the analyses are broadly defined as follows:

- **Level 1 Funding (Level 1) –** Funding needed to **provide the minimum** level of service (LOS) that meets both community-wide expectations and **existing** regulatory requirements over the 20-year IMP planning period.
- **Level 2 Funding (Level 2) –** Funding needed to **exceed the minimum** LOS that meets community-wide expectations and **more proactively** meets existing regulatory requirements over the 20-year IMP planning period.
- **Level 3 Funding (Level 3) –** Funding needed to **address all** forecasted infrastructure needs, and proactively meet **both** existing and forecasted regulatory requirements over the 20-year IMP planning period.

The City's existing (as of 2017) annual Sewer and Stormwater budgets are approximately $24.4 million and $2.4 million, respectively, with stormwater set to increase through 2020. If the City were to maintain the existing programs and associated levels of funding over the 20-year IMP planning period, the City's total investment would be approximately $558 million (in 2017 dollars). The funding scenarios evaluated as part of the alternatives identification process indicate that significant additional investments will be needed to address system needs, regulatory drivers, and the City's goals over that same timeframe. Potential additional investment levels (in 2017 dollars) range from $315 million to $509 million for wastewater treatment and collection, and from $91 million to $289 million for stormwater management. When added to the City's existing programs, the potential total costs (in 2017 dollars) to address wastewater and stormwater needs over then next 20 years are between $966 million and $1.37 billion (Figure 1).

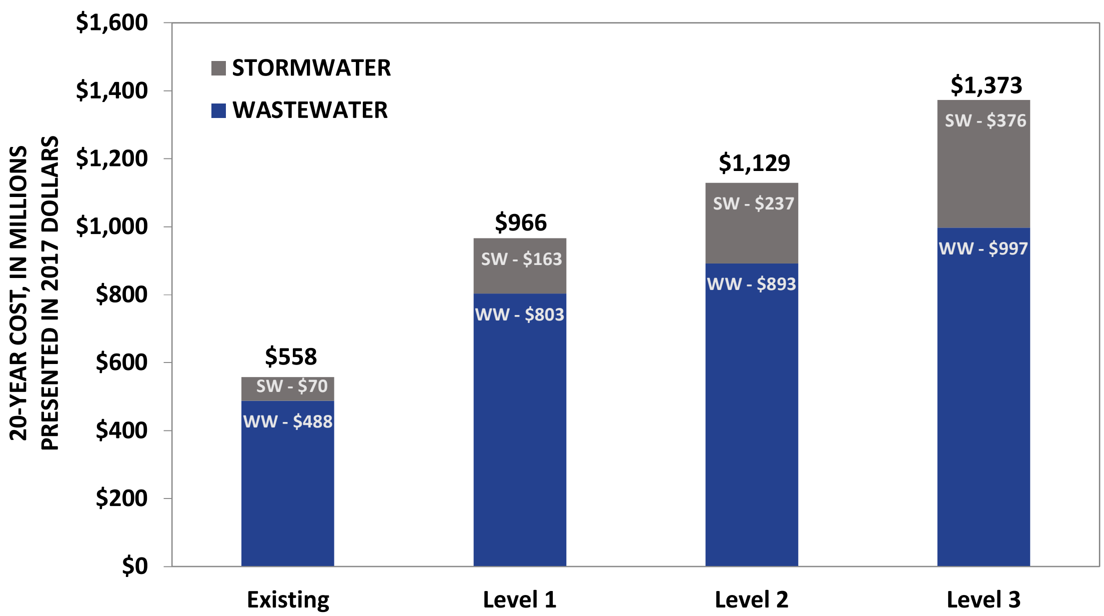

Figure 1. Summary of Potential Total 20-Year Wastewater and Stormwater Program Costs Identified during the IMP Alternatives Identification Process. Existing program costs were calculated assuming existing sewer and stormwater programs and associated budgets are maintained over the 20-year IMP planning period.

Section 3. MCDA Application

MCDA is a structured, quantitative technique used to solve planning problems that involve multiple decision criteria or objectives. When applied correctly, MCDA facilitates the critical thinking process in an open and transparent manner. Simplistically, an MCDA is conducted by scoring potential alternatives relative to a set of weighted criteria using a standardized rating system. After all alternatives are scored, the alternative with the highest total score should be the one that best addresses the underlying planning goals. By coupling MCDA scores with costs, the suite of alternatives that represents the best value can be identified.

A critical aspect of developing an MCDA tool is creating a decision framework that explicitly links the alternatives to the evaluation criteria, which represent the interests or priorities of the community (Figure 2). Sub-objectives are critical to the decision framework because they provide an objective means of linking alternatives to the community objectives. Once established, the framework enables decision makers to understand how the overall goal is linked to the individual alternatives and helps facilitate the scoring process.

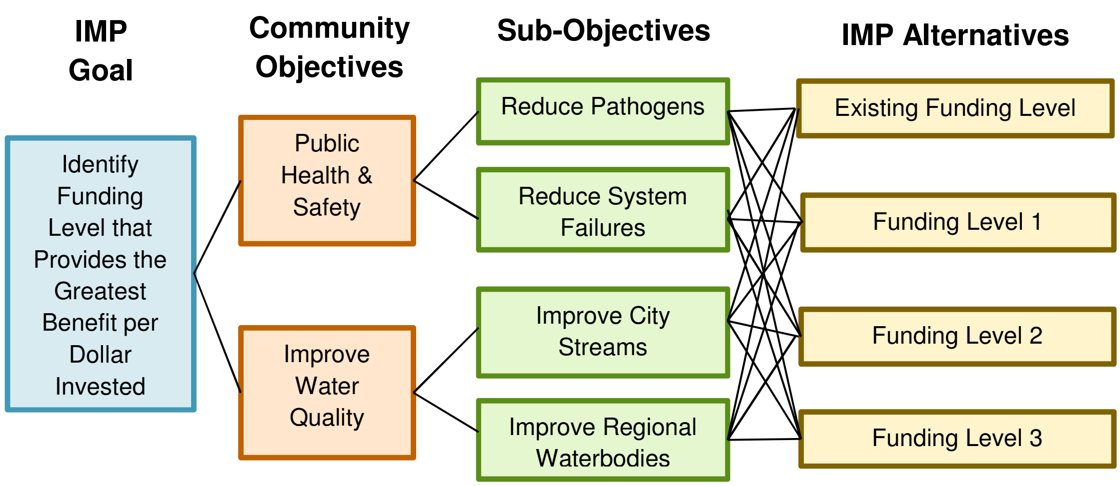

Figure 2. Conceptual Diagram of an MCDA Decision Framework. This diagram is for conceptual purposes only and does not reflect the final MCDA framework developed for the IMP.

The project team developed an MCDA tool to compare the existing and potential future levels of investment (Figure 1) and identify the level which appropriately balances overall costs with anticipated community benefits. The tool incorporates four basic components:

1. **Goal** - The goal of the MCDA evaluation was to select the funding level that provides the greatest benefit to the community.
2. **Alternatives** - The alternatives were defined by the project categories and funding levels described in Section 2.
3. **Weighted Evaluation Criteria** – Evaluation criteria represent the important issues or objectives that the alternatives are intended to address. In this MCDA, the evaluation criteria reflect important community objectives that were identified during outreach

activities conducted as part of the IMP process. The process used to identify and weight those commmunity objectives is explained in further detail in Section 3.1 below.

4. **Benefit Scores** – Benefit scores were developed to quantify how well each of the four funding level alternatives addressed the community objectives. A two-step process was used to develop the funding level benefit scores. This process is explained in further detail in Section 3.2 below. Once the funding level benefit scores were calculated, the alternatives were optimized by selecting a combination of project categories from among the four funding levels that resulted in the highest overall benefit score. This analysis is explained in further detail in Section 3.3 below.

The final MCDA tool and resulting benefit scores developed for the IMP are included as Attachment A. More detailed information regarding the evaluation criteria, scoring process, and optimization analysis used to evaluate the IMP alternatives are described below.

3.1 Weighted Evaluation Criteria

A key element of EPA's Integrated Planning Framework is conducting community outreach to maintain open communication with community stakeholders and ensure that all potential needs and priorities are considered in the planning process. The City's community outreach program (see Technical Memorandum 8) was structured such that input and results from outreach activities could be used to directly identify objectives that would be targeted by the MCDA.

Community priorities were structured based upon a triple bottom line (social, economic, and environmental) approach through the stakeholder engagement process to identify five community objectives for the IMP (Figure 3). The objectives were then weighted on a 0 to 1 scale (with a sum of 1) based on all outreach activities as well as input provided by Columbia City Council members during individual meetings. These five objectives represent the primary decision criteria used in the MCDA.

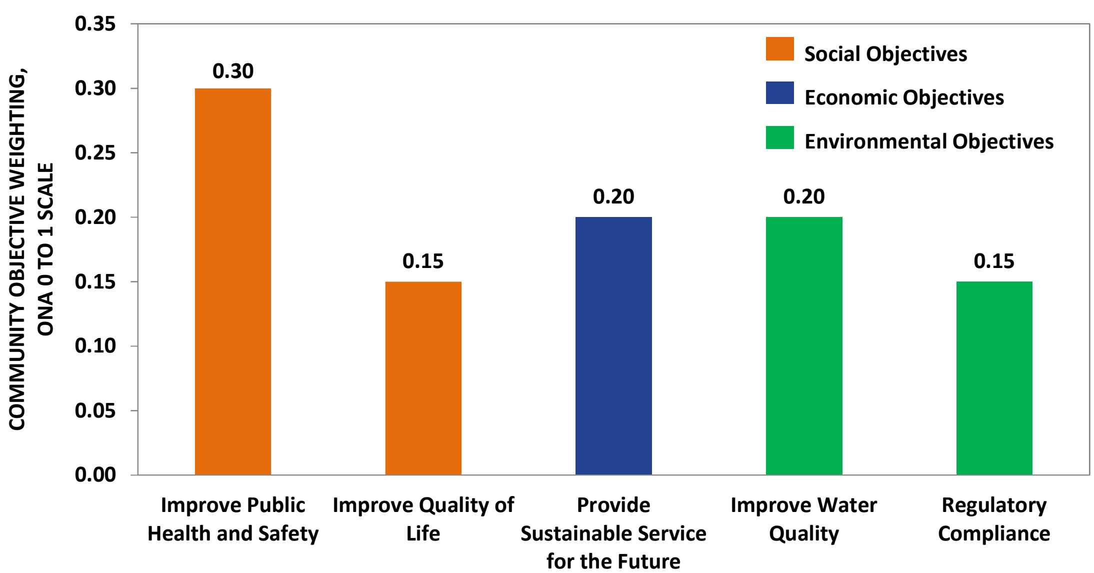

Figure 3. Final Triple Bottom Line Objectives and Prioritization Weightings Resulting from IMP Community Outreach Activities.

Once the primary objectives were defined and prioritized by the community, the project team worked collaboratively to review the remaining outreach results, and identify and weight 10 additional sub-objectives that more specifically characterized the five community objectives. Descriptions of each sub-objective identified for the MCDA are included in Attachment B. Objective and sub-objective weights were then multiplied together to develop a combined weight which reflects the relative importance of each sub-objective in the MCDA.

Table 2. Final Community Objectives, Sub-Objectives, and Priority Weightings using in the MCDA Evaluation. Note that community objective weights must total 1.0. Similarly, the sub-objective weights must total 1.0 for each corresponding community objective. The combined weight is the product of the objective and sub-objective weights.

Triple Bottom Line Criterion	Community Objective (Weight)	Sub-Objective (Weight)	Combined Weight
Social Objectives	Improve Public Health & Safety (0.30)	Reduce Pathogen Exposure (0.50)	0.15
		Reduce Safety Hazards from System Failures (0.50)	0.15
	Improve Quality of Life (0.15)	Provide Community-Wide Benefits (0.50)	0.075
		Reduce Potential for Property Damage (0.50)	0.075
Economic Objectives	Provide Sustainable Services for Future (0.20)	Renew Systems Beyond Effective Life (0.50)	0.1
		Improve Services to Underserved and Redeveloping Areas (0.30)	0.06
		Provide Adequate Services to Growing Areas (0.20)	0.04
Environmental Objectives	Improve Water Quality (0.20)	Protect or Improve Water Quality in City Streams (0.60)	0.12
		Protect Important Regional Waterbodies (0.40)	0.08
	Achieve Regulatory Compliance (0.15)	Proactively Address Clean Water Act Requirements (1.0)	0.15

3.2 Funding Level Benefit Score Development

Funding level benefit scores were developed based on a two-step analysis of the underlying project categories presented in Table 1. In the first step, the relative benefit of all wastewater collection, wastewater treatment, and stormwater management project categories were calculated for each sub-objective. Ratings were first assigned on a 0 to 5 scale to each project category to indicate how well it addressed an individual sub-objective relative to the other projects. Consensus- based ratings were assigned during a project team workshop. Ratings reflected a qualitative assessment of the anticipated benefits of each project on each sub-objective; a rating of 0 indicated that the project was not anticipated to benefit the sub-objective, whereas a rating of 5 indicated the highest benefit was expected.

For example, the project team determined that reducing building backups through improvements in the wastewater collection system would be more effective at reducing pathogen exposure to the public (sub-objective) than implementing chemical wastewater disinfection or stormwater runoff treatment. Therefore, reducing building backups was rated a “5” for that sub-objective and wastewater disinfection and stormwater runoff treatment were rated “3” and “1”, respectively. The same analysis was conducted across all sub-objectives.

Relative benefits (weights) were then calculated for each project category by dividing the assigned rating by the sum of the ratings for each sub-objective.

In the second step, the benefit provided by each project category was calculated across the four potential funding levels for each sub-objective. Ratings (also on a 0 to 5 scale) were assigned to indicate the benefit expected from implementing each project category as funding levels increase. For example, the project team determined that the existing funding level for wastewater collection system private common collector elimination (PCCE) project category reduces some pathogen exposure to the public (sub-objective) but could be more effective. Therefore, the existing funding level for this project was rated a "1". As PCCE funding increased to Level 1, Level 2, and Level 3, PCCE project ratings increased to "3", "4", and "5", respectively. The same analysis was conducted for each project category across all sub-objectives. These ratings were then multiplied by the weighting value developed in the first step described above to calculate a project benefit score for each funding level and sub-objective.

Project benefit scores were summed to develop the final funding level benefit scores (Figure 4). The final scores are normalized to the same 0 to 5 scale used to develop ratings and are helpful for evaluating the overall value produced by each funding level relative to all community objectives. The MCDA results indicate that the existing funding level produces the least amount of benefit (0.8 points) to the community and Level 3 funding produces the most benefit (5.0 points). According to the analysis, the greatest incremental increase in benefit occurs when moving from the existing funding to Level 1 (2.1 points). However, to meet the MCDA goal, this incremental increase in benefit must be evaluated with respect to the incremental costs of each additional level of funding.

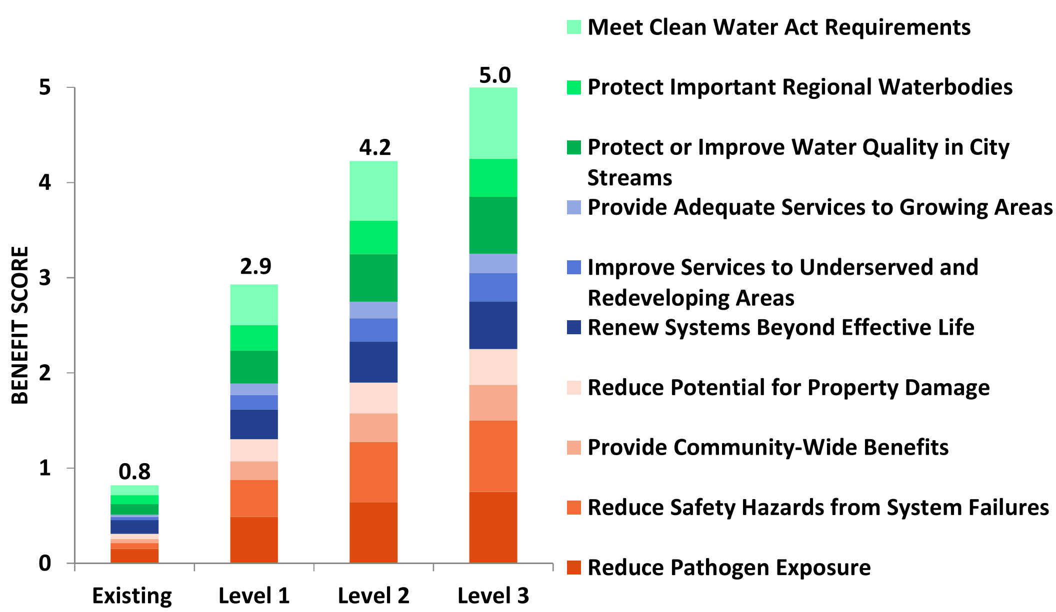

Figure 4. Final Funding Level Benefit Scores Calculated for the IMP. Benefit scores were normalized using a 0 to 5 scale. The orange, blue, and green colors presented in the figure correspond to the social, economic, and environmental sub-objectives, respectively.

The incremental increase in funding level benefit scores presented in Figure 4 were evaluated with respect to the total 20-year costs presented in Figure 1. Results of the evaluation show that Level 2 funding is the most cost-effective alternative because it produces the greatest benefit (0.79 points) for every $100 million dollars of total cost (Figure 5).

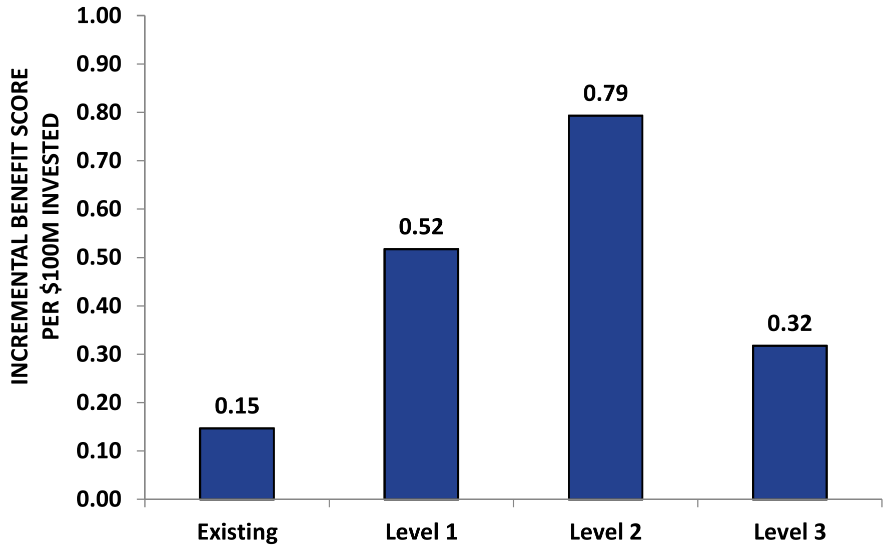

Figure 5. Incremental Benefit Produced by Each Funding Level Alternative per Additional $100 Million Invested.

3.3 Alternative Optimization

The project team recognized that although Level 2 funding represented the best value of the alternatives evaluated (Figure 5), an optimized funding level could be developed by combining the project categories that provided the best value from among the four funding levels. To develop the optimized suite of alternatives, the team divided the individual project category scores calculated in step two of the rating process described in Section 3.1 by their respective costs and selected the most cost-effective projects. The team found that Level 1 funding for most wastewater treatment and collection system project categories provided the best value. For the stormwater management system however, it was generally more beneficial to pursue Level 2 funding (Table 3). This conclusion is consistent with earlier IMP results (see Technical Memoranda 4 and 7) which highlighted the significance of the City's stormwater system needs relative to the funding currently available.

Table 3. Project Categories Selected to Form the Optimized Alternative.

System	Wastewater Treatment							Wastewater Collection										Stormwater Management						
Project Category	Wet Weather Imp.	Expanded Nitrification	Biological Nutrient Removal	Chemical Disinfection	Constructed Wetlands Impr.	Digester Rehabilitation	Digester Capacity Imp.	Wet Weather Program	Asset Management	System Renewal	System Capacity	Building Backups	Private Common Collectors	System Expansion	Cleaning Program	Pump Station Repair	Annual Improvements	SW Planning	System Assessment	System Renewal	Flood Control	Stream Erosion	Runoff Treatment	MS4 Program
Level 1		✓	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓				✓		✓
Level 2	✓				✓						✓								✓	✓	✓		✓	
Level 3																								

The analysis resulted in an optimized suite of alternatives with a total benefit score of 3.6 points and a total 20-year cost of $1.02 billion (in 2017 dollars). Results show that on a per dollar basis (Figure 6), the optimized alternative produces marginally greater benefit than the Level 2 funding alternative (0.81 points vs. 0.79 points per additional $100 million invested) while costing $114 million dollars less ($1.13 billion vs. $1.02 billion) over the 20-year planning period. The reduced cost of this best value suite of alternatives may be particularly important when considering overall program affordability. As a result, the optimized funding level is the preferred alternative for the IMP. Before implementing the optimized alternative, the City will evaluate its impact relative to community affordability and average residential monthly bills (see Technical Memorandum 10).

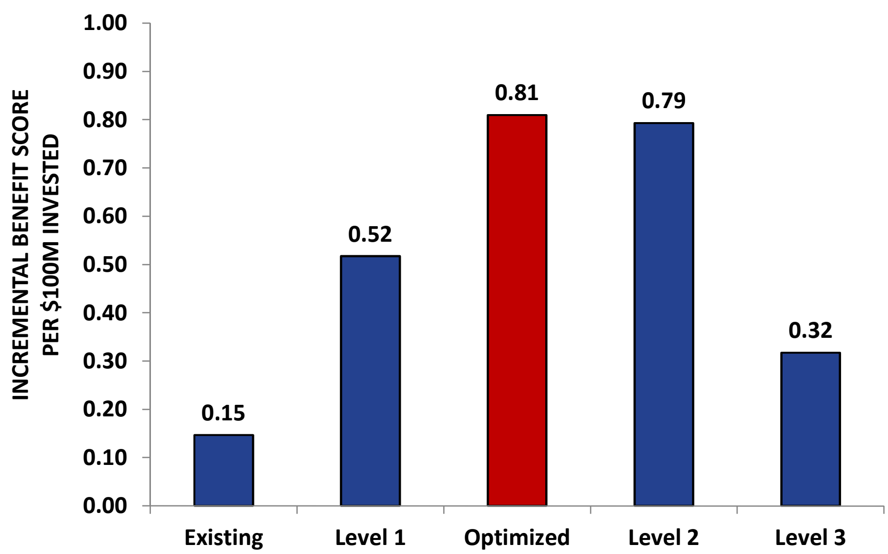

Figure 6. Comparison of the Incremental Benefit Produced by the Optimized and Original Funding Level Alternatives per Additional $100 Million Invested.

Section 4. Summary

During early phases of the IMP, the project team developed a series of wastewater treatment, wastewater collection, and stormwater management alternatives to address system needs, current and anticipated regulatory drivers, and City goals over the next 20 years (the IMP planning period). The alternatives included maintaining existing funding levels or increasing funding to three (Level 1, Level 2, and Level 3) potential higher levels designed to address system needs and goals in an increasingly proactively manner. Because the City is interested in implementing IMP wastewater and stormwater alternatives that cost-effectively provide the greatest benefit to the community over the 20-year planning period, the project team conducted an MCDA evaluation to identify the funding level that satisfied that goal.

MCDA is a structured, quantitative technique used to solve planning problems that involve multiple decision criteria or objectives. Decision criteria represent the important issues or objectives that the alternatives are intended to address. In this MCDA, the evaluation criteria reflect important community objectives that were identified during outreach activities conducted as part of the IMP process. Potential funding level alternatives were rated relative to the community objectives using a standardized rating system.

Initial results showed that the Level 2 funding alternative provided more benefit per dollar invested (Figure 5) than did the other funding levels evaluated. The project team then used the initial results and ratings to develop an optimized combination of Level 1 and Level 2 projects that produced the highest benefit (3.7 points) at the lowest 20-year cost ($1.02 billion, in 2017 dollars).

The optimized funding level is the preferred alternative for the IMP (Attachment C). Before implementing the optimized alternative, the City will evaluate its impact relative to community affordability and average residential monthly bills (see Technical Memorandum 10).

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Technical Memorandum 9

Attachments

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Attachment A. MCDA Tool and Final Benefit Scores Developed for the Columbia IMP.

Triple Bottom Line Criterion	Community Objective (Weight)	Sub-Objective (Weight)	Combined Weight	Collection System					Wastewater Treatment					Stormwater System				
				Existing	Level 1	Level 2	Level 3	Optimized	Existing	Level 1	Level 2	Level 3	Optimized	Existing	Level 1	Level 2	Level 3	Optimized
Social Objectives	Improve Public Health & Safety (0.30)	Reduce Pathogen Exposure (0.50)	0.15	0.63	1.89	2.40	2.86	2.00	0.14	0.74	0.94	1.14	0.86	0.23	0.63	0.89	1.00	0.66
		Reduce Safety Hazards from System Failures (0.50)	0.15	0.16	0.47	0.63	0.79	0.47	0.00	0.00	0.00	0.00	0.00	0.26	2.11	3.58	4.21	3.26
	Improve Quality of Life (0.15)	Provide Community-Wide Benefits (0.50)	0.075	0.17	0.67	0.93	1.17	0.73	0.00	0.20	0.27	0.33	0.23	0.43	1.77	2.80	3.50	2.33
		Reduce Potential for Property Damage (0.50)	0.075	0.58	1.73	2.04	2.31	1.73	0.00	0.00	0.00	0.00	0.00	0.12	1.35	2.23	2.69	1.92
Economic Objectives	Provide Sustainable Services for Future (0.20)	Renew Systems Beyond Effective Life (0.50)	0.1	0.37	1.00	1.32	1.58	1.00	0.79	1.26	1.42	1.58	1.42	0.26	0.84	1.58	1.84	1.58
		Improve Services to Underserved and Redeveloping Areas (0.30)	0.06	0.43	1.18	1.64	2.14	1.32	0.00	0.00	0.00	0.00	0.00	0.18	1.39	2.29	2.86	2.29
		Provide Adequate Services to Growing Areas (0.20)	0.04	0.33	0.96	1.44	1.85	1.19	0.00	0.81	0.96	1.11	0.85	0.22	1.26	1.85	2.04	1.67
Environmental Objectives	Improve Water Quality (0.20)	Protect or Improve Water Quality in City Streams (0.60)	0.12	0.70	1.48	1.91	2.42	1.61	0.00	0.27	0.36	0.45	0.36	0.24	1.12	1.67	2.12	1.30
		Protect Important Regional Waterbodies (0.40)	0.08	0.21	0.63	0.83	1.04	0.63	0.63	1.79	2.21	2.50	2.00	0.33	0.92	1.25	1.46	1.00
	Achieve Regulatory Compliance (0.15)	Proactively Address Clean Water Act Requirements (1.0)	0.15	0.21	0.63	1.03	1.45	1.16	0.26	1.58	2.08	2.50	1.82	0.21	0.63	0.87	1.05	0.71
			Weighted Sum	**0.38**	**1.07**	**1.42**	**1.76**	**1.16**	**0.19**	**0.70**	**0.87**	**1.03**	**0.80**	**0.25**	**1.16**	**1.85**	**2.21**	**1.61**

Total Benefit Scores	
Existing	**0.82**
Level 1	**2.93**
Level 2	**4.14**
Level 3	**5.00**
Optimized	**3.57**

Notes:
Red values are the benefit scores that resulted from the rating and scoring process described in Section 3.2.
Community objective weights must total 1.0. Similarly, sub-objective weights must total 1.0 for each objective.
The combined objective weight is the product of the objective and sub-objective weights.
Weighted sums represent the summed product of all combined objective weights and benefit scores for each column.
Total benefit scores are the sum of the weighted sums for each funding level alternative.

Attachment B. Community Sub-Objective Definitions.

Community Objective	Sub-Objective
Improve Public Health and Safety Reduce the potential health and safety impacts related to infrastructure needs in the City. Examples include health impacts associated with poor water quality and safety impacts related to catastrophic failures like road sinkholes.	**Reduce Pathogen Exposure –** Reduce the potential for exposure to bacteria and other pathogens in streams, lakes, and buildings.
	Reduce Safety Hazards from System Failures – Reduce the potential for catastrophic infrastructure failures that impact public health safety such as road collapses, sinkholes, pipe failures, and flooding of roads and structures.
Improve Quality of Life Enhance community well-being and satisfaction relative to sewer and stormwater infrastructure. Examples include benefits such as minimizing public or private property damage, improving aesthetics, changing neighborhood appearance or property values, and creating opportunities for green infrastructure or other open spaces.	**Provide Community-Wide Benefits –** Enhance well-being or satisfaction with respect to sewer and stormwater infrastructure or community enhancements like green stormwater infrastructure for more than one group of ratepayers or in more than one area of the City.
	Reduce Potential for Property Damage – Reduce the potential for damage to public and private property that is caused by or related to public infrastructure needs.
Provide Sustainable Services for the Future Minimize service disruptions, limit infrastructure failures, and maintain efficient and effective sewer and stormwater services for new and existing customers.	**Renew Systems beyond Physical Effective Life –** Maintain a sustainable infrastructure repair or replacement rate to provide efficient and effective services.
	Improve Services to Underserved and Redeveloping Areas – Provide enhanced services and performance to existing customers in underserved or redeveloping areas.
	Provide Adequate Services to Growing Areas – Provide enhanced services and performance to new customers and to help foster economic growth.
Improve Water Quality Reduce pollutants and improve habitat in streams, lakes, and wetlands impacted by the City.	**Protect or Improve Water Quality in City Streams and Lakes –** Protect water quality in streams and lakes located within the City that provide recreational opportunities and overall community benefit.
	Protect Important Regional Waterbodies – Protect water quality in nearby unique and high quality waterbodies such as the Missouri River, Eagle Bluffs Conservation Area, and Bonne Femme Creek.
Achieve Regulatory Compliance Meet or exceed anticipated Clean Water Act and associated regulatory requirements over the 20-year IMP planning period.	**Proactively Address Existing and Future Clean Water Act Requirements –** Meet existing or future Clean Water Act requirements that are or will be outlined in applicable wastewater and stormwater National Pollution Discharge Elimination System permits or other regulatory obligations.

Attachment C. Detailed Cost Forecasts.

Table C.1. Optimized Wastewater Collection System Capital and Programmatic Cost Forecast, in 2017 Dollars. Estimates include potential additional capital, operation and maintenance, and planning costs over the IMP planning period. *Note that costs were allocated to specific years for planning purposes only and help facilitate comparisons between the alternative levels. Actual annual costs and timing of projects will be addressed in the final IMP.*

Columbia Collection System
Capital and Programmatic Cost Estimates - Optimized Level of Service

Project Category	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Wet-Weather Program Planning and Management	$ -	$ -	$ 400,000	$ 400,000	$ 400,000	$ 305,000	$ 280,000	$ 280,000	$ 280,000	$ 280,000
Asset Management			$ 75,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000
System Renewal Program	$ -	$ -	$ -	$ 1,200,000	$ 2,700,000	$ 2,700,000	$ 2,700,000	$ 2,700,000	$ 2,700,000	$ 2,700,000
System Capacity Enhancement	$ -	$ -	$ -	$ -	$ -	$ 4,000,000	$ 4,000,000	$ 4,000,000	$ 4,000,000	$ 4,000,000
Building Backup Allevation			$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000			
Private Common Collector Elimination	$ -	$ -	$ -	$ -	$ -	$ 610,000	$ 765,000	$ 780,000	$ 893,858	$ 865,691
System Expansion	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,000,000
Cleaning Program	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 380,000	$ 130,000
Pump Station R/R	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 252,450	$ 885,358	$ -
Other - Annual Sewer Improvement Cost	$ -	$ -	$ 1,000,000	$ 500,000	$ -	$ -	$ -	$ 1,000,000	$ 1,000,000	$ 1,000,000
Annual Total	**$ -**	**$ -**	**$ 1,575,000**	**$ 2,275,000**	**$ 3,275,000**	**$ 7,790,000**	**$ 7,920,000**	**$ 9,087,450**	**$ 10,214,216**	**$ 11,050,691**
Cumulative Total	**$ -**	**$ -**	**$ 1,575,000**	**$ 3,850,000**	**$ 7,125,000**	**$ 14,915,000**	**$ 22,835,000**	**$ 31,922,450**	**$ 42,136,666**	**$ 53,187,357**

Columbia Collection System
Capital and Programmatic Cost Estimates - Optimized Level of Service

Project Category	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036
Wet-Weather Program Planning and Management	$ 280,000	$ 280,000	$ 280,000	$ 280,000	$ 280,000	$ 305,000	$ 280,000	$ 280,000	$ 280,000	$ 280,000
Asset Management	$ 75,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000
System Renewal Program	$ 2,700,000	$ 2,700,000	$ 2,700,000	$ 2,700,000	$ 2,700,000	$ 2,700,000	$ 2,700,000	$ 2,700,000	$ 2,700,000	$ 2,700,000
System Capacity Enhancement	$ 4,000,000	$ 4,000,000	$ 4,000,000	$ 4,000,000	$ 4,000,000	$ 4,000,000	$ 4,000,000	$ 4,000,000	$ 4,000,000	$ 4,000,000
Building Backup Allevation										
Private Common Collector Elimination	$ 211,111	$ 211,111	$ 211,111	$ 211,111	$ 211,111	$ 211,111	$ 211,111	$ 211,111	$ 211,111	$ 211,111
System Expansion	$ 2,000,000	$ 2,000,000	$ 2,000,000	$ 2,000,000	$ 2,000,000	$ 2,000,000	$ 2,000,000	$ 2,000,000	$ 2,000,000	$ 2,000,000
Cleaning Program	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 380,000	$ 130,000
Pump Station R/R	$ -	$ -	$ -	$ -	$ 776,220	$ -	$ -	$ -	$ -	$ -
Other - Annual Sewer Improvement Cost	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000
Annual Total	**$ 10,396,111**	**$ 10,396,111**	**$ 10,396,111**	**$ 10,396,111**	**$ 11,172,331**	**$ 10,421,111**	**$ 10,396,111**	**$ 10,396,111**	**$ 10,646,111**	**$ 10,396,111**
Cumulative Total	**$ 63,583,468**	**$ 73,979,579**	**$ 84,375,690**	**$ 94,771,801**	**$ 105,944,132**	**$ 116,365,243**	**$ 126,761,354**	**$ 137,157,465**	**$ 147,803,576**	**$ 158,199,687**

Table C.2. Optimized Wastewater Treatment System Capital and Programmatic Cost Forecast, in 2017 Dollars. Estimates include potential additional capital, operation and maintenance, and planning costs over the IMP planning period. Because the City's 2018 budget is already in development, the IMP assumes that no additional funding would be dedicated to any of the three levels described above until 2019. *Note that costs were allocated to specific years for planning purposes only and help facilitate comparisons between the alternative levels. Actual annual costs and timing of projects will be addressed in the final IMP.*

Columbia Wastewater Treatment System
Capital and Programmatic Cost Estimates - Optimized Level of Service

Project Category	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Wet Weather Improvements	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Expanded Nitrification	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Biological Nutrient Removal	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Chemical Disinfection	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Constructed Wetlands Improvements	$ -	$ -	$ -	$ -	$ -	$ 2,621,411	$ 2,621,411	$ 2,621,411	$ 2,621,411	$ 2,621,411
Digester Rehabilitation	$ -	$ -	$ -	$ 8,711,700	$ -	$ -	$ -	$ -	$ -	$ -
Digester Capacity	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 4,234,000	$ 49,100
Annual Total	**$ -**	**$ -**	**$ -**	**$ 8,711,700**	**$ -**	**$ 2,621,411**	**$ 2,621,411**	**$ 2,621,411**	**$ 6,855,411**	**$ 2,670,511**
Cumulative Total	**$ -**	**$ -**	**$ -**	**$ 8,711,700**	**$ 8,711,700**	**$ 11,333,111**	**$ 13,954,522**	**$ 16,575,933**	**$ 23,431,344**	**$ 26,101,856**

Columbia Wastewater Treatment System
Capital and Programmatic Cost Estimates - Optimized Level of Service

Project Category	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036
Wet Weather Improvements	$ 48,927,300	$ 309,200	$ 309,200	$ 309,200	$ 309,200	$ 309,200	$ 309,200	$ 309,200	$ 309,200	$ 309,200
Expanded Nitrification	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 38,771,200	$ 661,200
Biological Nutrient Removal	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Chemical Disinfection	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 3,874,637	$ 303,237
Constructed Wetlands Improvements	$ 2,621,411	$ 2,621,411	$ 2,621,411	$ 2,621,411	$ -	$ -	$ -	$ -	$ -	$ -
Digester Rehabilitation	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Digester Capacity	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100
Annual Total	**$ 51,597,811**	**$ 2,979,711**	**$ 2,979,711**	**$ 2,979,711**	**$ 358,300**	**$ 358,300**	**$ 358,300**	**$ 358,300**	**$ 43,004,137**	**$ 1,322,737**
Cumulative Total	**$ 77,699,667**	**$ 80,679,378**	**$ 83,659,089**	**$ 86,638,800**	**$ 86,997,100**	**$ 87,355,400**	**$ 87,713,700**	**$ 88,072,000**	**$ 131,076,137**	**$ 132,398,874**

Table C.3. Optimized Stormwater System Capital and Programmatic Cost Forecast, in 2017 Dollars. Estimates include potential additional capital, operation and maintenance, and planning costs over the IMP planning period. Because the 2015 voter-approved rate increase is scheduled to continue through 2020, the IMP assumes that no additional funding would be dedicated to any of the three levels described above until 2021. *Note that costs were allocated to specific years for planning purposes only and help facilitate comparisons between the alternative levels. Actual annual costs and timing of projects will be addressed in the final IMP.*

Columbia Stormwater System
Capital and Programmatic Cost Estimates - Optimized Level of Service

Project Category	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Stormwater Planning	$ -	$ -	$ -	$ -	$ 180,000	$ 180,000	$ 180,000	$ 180,000	$ 180,000	$ 50,000
Condition Assessment and Cleaning	$ -	$ -	$ -	$ -	$ 83,468	$ 83,468	$ 83,468	$ 83,468	$ 130,000	$ 130,000
System Renewal Program	$ -	$ -	$ -	$ -	$ 4,217,341	$ 4,217,341	$ 4,217,341	$ 4,217,341	$ 4,217,341	$ 4,217,341
Flood Reduction	$ -	$ -	$ -	$ -	$ 2,145,000	$ 2,095,000	$ 2,095,000	$ 2,095,000	$ 2,095,000	$ 2,095,000
Stream Erosion	$ -	$ -	$ -	$ -	$ 172,500	$ 172,500	$ 172,500	$ 172,500	$ 172,500	$ 172,500
Runoff Treatment	$ -	$ -	$ -	$ -	$ 2,669,081	$ 2,669,081	$ 2,669,081	$ 2,669,081	$ 2,669,081	$ 2,669,081
Stormwater Management Program	$ -	$ -	$ -	$ -	$ -	$ 180,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000
Annual Total	**$ -**	**$ -**	**$ -**	**$ -**	**$ 9,467,389**	**$ 9,597,389**	**$ 9,547,389**	**$ 9,547,389**	**$ 9,593,921**	**$ 9,463,921**
Cumulative Total	**$ -**	**$ -**	**$ -**	**$ -**	**$ 9,467,389**	**$ 19,064,779**	**$ 28,612,168**	**$ 38,159,557**	**$ 47,753,479**	**$ 57,217,400**

Columbia Stormwater System
Capital and Programmatic Cost Estimates - Optimized Level of Service

Project Category	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036
Stormwater Planning	50000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000
Condition Assessment and Cleaning	130000	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000	$ 130,000
System Renewal Program	4217340.5	$ 4,217,341	$ 4,217,341	$ 4,217,341	$ 4,217,341	$ 4,217,341	$ 4,217,341	$ 4,217,341	$ 4,217,341	$ 4,217,341
Flood Reduction	2095000	$ 2,095,000	$ 2,095,000	$ 2,095,000	$ 2,145,000	$ 2,095,000	$ 2,095,000	$ 2,095,000	$ 2,095,000	$ 2,095,000
Stream Erosion	172500	$ 172,500	$ 172,500	$ 172,500	$ 172,500	$ 172,500	$ 172,500	$ 172,500	$ 172,500	$ 172,500
Runoff Treatment	2669080.835	$ 2,669,081	$ 2,759,081	$ 2,759,081	$ 2,759,081	$ 2,759,081	$ 2,759,081	$ 2,759,081	$ 2,759,081	$ 2,759,081
Stormwater Management Program	130000	$ 130,000	$ 130,000	$ 384,000	$ 334,000	$ 334,000	$ 334,000	$ 334,000	$ 334,000	$ 334,000
Annual Total	**$ 9,463,921**	**$ 9,463,921**	**$ 9,553,921**	**$ 9,807,921**	**$ 9,807,921**	**$ 9,757,921**	**$ 9,757,921**	**$ 9,757,921**	**$ 9,757,921**	**$ 9,757,921**
Cumulative Total	**$ 66,681,321**	**$ 76,145,243**	**$ 85,699,164**	**$ 95,507,085**	**$ 105,315,007**	**$ 115,072,928**	**$ 124,830,849**	**$ 134,588,771**	**$ 144,346,692**	**$ 154,104,613**

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Columbia Wastewater and Stormwater IMP

Attachment O

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Our Columbia Waters
Integrated Management Plan
Wastewater & Stormwater

Technical Memorandum 10
Residential Affordability and Socioeconomic Evaluation

Columbia Wastewater and Stormwater Integrated Management Plan

Columbia, Missouri
September 28, 2018

HDR

Geosyntec consultants
Shockey Consulting Services, llc
TREKK Design Group, LLC

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Section 1. Introduction and Objectives

The City of Columbia, Missouri (City) is preparing an Integrated Management Plan (IMP) for the City's Sewer and Storm Water Utilities. The goal of the IMP is to develop an adaptable and affordable long-term plan that addresses the City's wastewater and stormwater management needs and meets Clean Water Act requirements. The IMP will be developed based on guidance presented in US Environmental Protection Agency's (EPA) *Integrated Municipal Stormwater and Wastewater Planning Approach Framework*[1].

As part of the IMP process, the City and their project team developed a series of potential wastewater treatment, wastewater collection, and stormwater system alternatives and corresponding funding requirements to address infrastructure and environmental needs that are important to Columbia residents. The potential alternatives were evaluated using a multiple criteria decision analysis (MCDA) tool developed from feedback obtained from community outreach activities. The MCDA was used to quantitatively evaluate the costs of the various alternatives relative to their benefits. Through application of this tool, the project team recommended a suite of wastewater and stormwater alternatives that provide the best value to the community. More detailed information regarding the MCDA process is presented in Technical Memorandum 9.

The MCDA evaluation described above was limited to quantifying the costs and benefits of potential alternatives, and did not assess the impact of the increased cost of utility services on the City's ratepayers. EPA allows state regulatory agencies to consider financial and economic impacts when developing water quality standards regulations or implementing water pollution control measures. However, the tools that EPA has historically relied upon for conducting these evaluations are narrowly-focused and did not provide communities sufficient flexibility to fully consider local socioeconomic considerations that may impact the financial capability of the municipality and residential ratepayers.

During the 1990s, EPA published guidance documents outlining analyses municipalities could use to assess the financial impacts of complying with water quality standards regulations[2] and developing combined sewer overflow control programs[3]. Both guidance documents outline a two-part financial capability matrix. The matrix evaluates the cost of wastewater services per household (Residential Indicator) relative to both the community median household income (MHI) and the ability of the community to finance the required construction (Permittee Financial Capability Indicators). The matrix uses this information in an attempt to predict whether or not a community will experience substantial socioeconomic impacts as a result of implementing projects needed to comply with Clean Water Act requirements.

[1] Stoner, N. and C. Giles. 2012. Integrated Municipal Stormwater and Wastewater Planning Approach Framework. June 5, 2012. Washington D.C.

[2] Davies, T. 1995. Economic Guidance for Water Quality Standards Workbook. Office of Science and Technology. Washington, DC. EPA-823-B-95-002.

[3] EPA. 1997. Combined Sewer Overflows – Guidance for Financial Capability Assessment and Schedule Development: Final. Office of Wastewater Management. Washington, D.C. EPA 832-B-97-004.

For the Residential Indicator (RI) evaluation specifically, EPA suggests using a "screener" approach to establish whether or not a community can fund projects by categorizing impacts as a low, mid-range, or high burden. EPA considers financial impacts to be low if average bills are less than 1% of community MHI, mid-range if average bills are between 1% and 2% of MHI, and high if they are greater than 2% of MHI. In their guidance documents, EPA's assumption is that communities with a low burden (average bills less than 1% of MHI) can pay for additional projects and programs without incurring any substantial impacts and therefore do not need to evaluate the additional indicators for second part of the financial capability matrix.

In Columbia, the average residential sewer bill is approximately $27.50 per month (assuming 5,000 gallons per month consumption) and the average residential stormwater bill is $1.66 per month. When compared to the MHI of the City (approximately $45,000), these bills collectively equate to a RI of approximately 0.74%. According to the EPA economic guidance, this result suggests that the financial burden of existing wastewater and stormwater services is low and ratepayers could potentially afford to spend between $38 and 75 per month (1 to 2% of MHI) for additional wastewater and stormwater services, depending on Columbia's financial and socioeconomic strength.

A limitation to EPA's RI approach for evaluating affordability is that it is not useful for characterizing impacts on disadvantaged segments of the community that may be disproportionately impacted by increased sewer and stormwater bills. This issue is especially important in Columbia because the City has identified improving social equity as one of their top five strategic planning priorities[4]. In 2014, EPA issued revised economic guidance to help address this limitation and define expectations for municipalities conducting affordability analyses in the context of an integrated plan[5]. The new guidance clarified that additional, community-specific information may be necessary to develop a "more accurate and complete picture" of financial capability. The Missouri Department of Natural Resources (MDNR) also recognizes the importance of allowing communities flexibility when evaluating affordability for integrated planning[6] or permitting purposes. Since the passage of Missouri's municipal affordability statutes (644.145 RSMo), MDNR has developed robust processes for evaluating the municipal financial capability to afford wastewater and stormwater programs and has emerged as a leading state agency in these assessments.

An additional complication with assessing affordability in Columbia is that residential ratepayers include both customers who reside within the City limits and Boone County Regional Sewer District (BCRSD) customers who reside outside of the City limits. The City and BCRSD operate under a multiple agreements whereby the City accepts wastewater flows from some BCRSD facilities in order to provide regional treatment services. The City understands that future Sewer Utility rate increases will impact both City and BCRSD ratepayers. However, a focused analysis of potential impacts to BCRSD customers was not conducted because sufficiently detailed socioeconomic data specific to those users are not readily available.

[4] City of Columbia, Missouri. 2015. Strategic Plan 2016-2019. https://www.como.gov/wp-content/uploads/2016-2019-Strategic-Plan.pdf
[5] Kopocis, K., and C. Giles.2014. Financial Capability Assessment Framework for Municipal Clean Water Act Requirements. Office of Enforcement and Compliance Assurance. Washington, D.C.
[6] Hirschvogel, L. 2016. Missouri Integrated Planning Framework. Water Protection Program. Jefferson City, Missouri.

Therefore, the purpose of this memorandum is to evaluate and identify potential residential affordability issues associated with implementing the preferred wastewater and stormwater IMP alternatives identified in Technical Memorandum 9. The affordability analysis includes a review of both overall existing socioeconomic conditions in the City and potential future financial impacts on residential City ratepayers related to increased wastewater and stormwater services costs.

Section 2. City-Wide Socioeconomic Evaluation

Evaluating the current socioeconomic conditions in Columbia is important because it helps identify a baseline from which to measure future changes in the community that could influence both the implementation schedule for future IMP projects and the ability of ratepayers to fund those projects. Because there is no specific metric or ratio that is appropriate for adequately characterizing overall socioeconomic conditions in a community, a group of indicators are typically reviewed when conducting these analyses.

The evaluation focused on population trends, unemployment rates, poverty rates, and income distributions to develop a broad understanding of city-wide socioeconomic conditions in Columbia. In Section 3, a more refined group of indicators was used to better characterize existing conditions in specific neighborhoods and census tracts within the City.

2.1 Population Trends

Official population counts occur every 10 years as part of the decennial census. In between censuses, the Census Bureau's Population Estimates Program (PEP) provides the official estimated population based on current migration, birth, and death statistics. At the time of the 2010 Census, the population of Columbia was 108,500. The PEP estimate indicates that the population increased to 119,108 by 2015, which indicates that the City's population has been increasing at a rate of approximately 2% each year (Figure 1).

Columbia is also home to the University of Missouri (MU), Columbia College, and Stephens College. These higher education institutions have a combined student enrollment of nearly 40,000 people. The 2015 American Community Survey[7] (ACS) estimates that 31,000 of those students live in the City limits both on and off-campus, which represents an increase of approximately 2,200 students since 2010. Those 2,200 resident students represent approximately 21% of the City's total population growth since 2010 (Figure 1).

[7]. The ACS is a tool developed by the U.S. Census Bureau to estimate population statistics between decennial (every 10 years) censuses. The ACS 5-year estimates are based on 60 months of survey data and provide the most reliable information at a higher level of resolution; however, there is a margin of error associated with all ACS estimates that must be considered as part of the data interpretation. The 5-year ACS data are labeled with the end year of the 5-year period included in the multi-year estimate. For instance, the 5-year ACS data for 2015 includes 2011, 2012, 2013, 2014, and 2015 information.

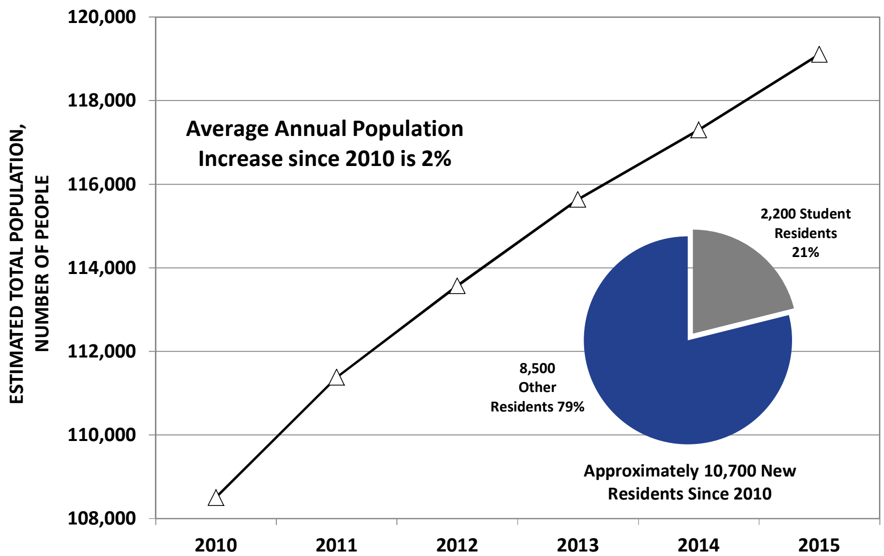

Figure 1. Columbia Population Changes since 2010.

2.2 Unemployment and Poverty Rates

The unemployment rate in Columbia (4.8% in 2015) has decreased since 2011 and is currently lower than both the State of Missouri (7.5% in 2015) and the overall national unemployment rate (8.3% in 2015). Reduced unemployment rates are an indicator that Columbia's overall economy is strong relative to other communities in the state.

Even though the unemployment rate in Columbia is lower than the state and national average, the portion of the population living below the poverty level (24.4%) is higher (Figure 2). However, the poverty level estimate is influenced by the resident college student population. Traditional poverty estimates exclude individuals who live in dormitories but include undergraduate and graduate students living in off-campus housing in the City limits. These students generally report low incomes and contribute to higher poverty rate estimates. When corrected for college students[8], the estimated average poverty level in Columbia drops from 24.4% to 13%, which is lower than levels reported for Missouri and the United States (Figure 2).

[8]Annie Rorem and Luke Juday. "How to modify poverty calculations for college towns." March 7, 2016. http://statchatva.org/2016/03/07/how-to-modify-poverty-calculations-for-college-towns/,accessed February 16, 2017.

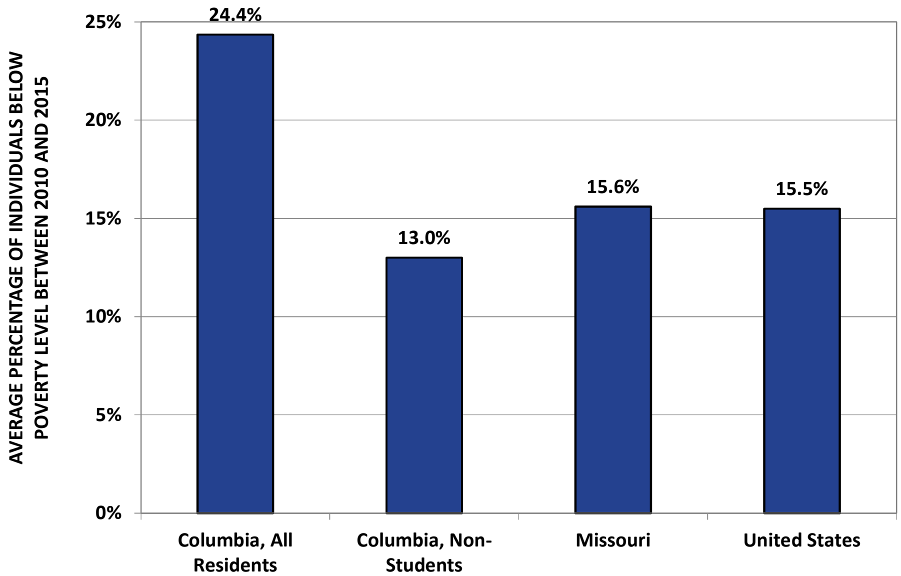

Figure 2. Comparison of 2015 Estimated Average Individual Poverty Rates in Columbia, Missouri, and the United States.

2.3 Median Income and Distribution

City-wide median income values provide a general estimate of income levels for the community. Median household income (MHI) is the 50th percentile of the sum of incomes of the householder and all other individuals in the household 15 years old and over, regardless of whether they are related to the householder. MHI estimates exclude students living in on-campus housing (e.g., dormitories, referred to in the census data as group quarters), but likely include those students living in off-campus housing (e.g. apartments, houses, condominiums). The MHI for Columbia is approximately $45,000 (Statewide MHI = $48,000).

As described in the previous section, when resident students were excluded from the poverty rate calculation, the estimated poverty rate decreased. Therefore, it is reasonable to expect that resident students have a similar impact on MHI in Columbia (skewing it downward). To address the potential impact of students on income estimates, median family income (MFI) was evaluated. MFI is the 50th percentile of the sum of incomes of all related members of a household who are 15 years or over. The MFI in Columbia is approximately $76,000 (Statewide MFI = $61,000). MFI likely provides a better indication of the median income of the City's permanent residents.

Although Columbia MHI and MFI estimates provide a broad measure of resident income, it is necessary to understand the distribution of incomes across the City to better characterize the potential hardships that residents who fall below the median may be facing. The 2015 ACS data show that number of households (13%) in Columbia that report incomes below $10,000 is higher than the number of families (4%, Figure 3). These results reinforce the impact of the resident student population on socioeconomic metrics in Columbia. When resident students are excluded from the evaluation through application of the MFI, the percent of residents in each of the low-income brackets is more evenly distributed (Figure 3).

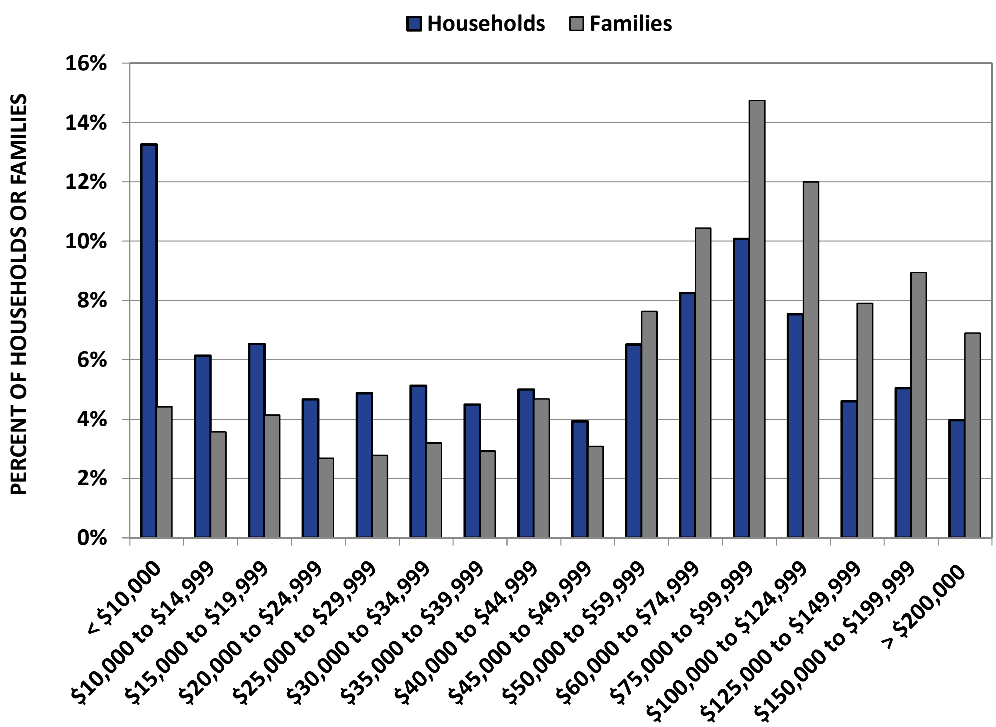

Figure 3. Household and Family Income Distributions in Columbia.

The review of indicators for Columbia shows that socioeconomic conditions in the City are generally strong when compared to state and national averages. However, there are disadvantaged segments of the community which warrant additional consideration. More specifically, the review demonstrates:

- Columbia's population has steadily grown. Since 2010, the population has increased by approximately 2% per year (approximately 10,700 people total).
- Approximately 21% (2,200 people) of the recent population increase can be attributed to an increase in college students who live within the City limts.
- Unemployment in the City (4.8%) is lower than state (7.5%) and national (8.3%) averages.
- The City's overall poverty rate (24.4%) is higher than state (15.6%) and national averages (15.5%) but is influenced by the resident college student population. When adjusted to account for resident college students, the rate decreases to 13%.
- The City's MHI is approximately $45,000, which is lower than the state estimate of $48,000. A review of the underlying income distribution across the City suggests that

college students living in off-campus housing report low incomes and reduce the overall MHI estimate for the City.

- The City's MFI is approximately $76,000, higher than the state estimate of $61,000. Because MFI estimates only include income from related individuals living in the same household, these results suggest that resident college students influence income metrics in the City.

Section 3. Census Tract Socioeconomic Evaluation

As discussed in Section 2, overall socioeconomic conditions in Columbia are generally strong but there are disadvantaged segments of the community which warrant additional consideration. In their most recent Strategic Plan[9], the City identified improving social equity as one of their top five priorities over the next three years. The City's goal is to improve social equity across the entire community and has identified three neighborhoods on which to initially focus their resources. The neighborhoods are located in north, central, and east Columbia. These neighborhoods were selected based on socioeconomic metrics related to income, poverty, unemployment housing, health care, crime rates, nutrition, and participation in assistance programs (Attachment A). The City is currently working with residents in these neighborhoods to develop actions aimed at improving equity issues.

To more closely align the IMP with goals outlined in the Strategic Plan, the City-wide evaluation presented in Section 2 was refined to provide a spatial understanding of socioeconomic conditions across Columbia and identify specific areas of the City that may be disadvantaged. Census tract boundaries were used to guide the evaluation because census tracts provide the highest resolution datasets for the socioeconomic metrics evaluated. Twenty-five census tracts are within or intersect Columbia's city limits (Attachment A). Fifteen of the census tracts evaluated span portions of both the City and Boone County and likely represent data from a mixture of City and BCRSD ratepayers.

The project team identified eight socioeconomic indicators of economic stress that could be used to identify disadvantaged areas of the City. These indicators are similar to those used to identify the City's three Strategic Plan neighborhoods and include MHI, MFI, poverty rates, occupancy rates, homeowner housing costs, renter housing costs, supplemental nutrition assistance program (SNAP) participation rates, and health insurance coverage rates. Using these indicators, the project team evaluated data from each census tract to determine if the tract met the following economic stress thresholds:

- MHI less than the City MHI ($45,000);
- MFI less than the City MFI ($76,000);
- MFI less than the Department of Housing and Urban Development (HUD) definition of low income for the City (less than 80% of the MFI of the City, $60,800);
- MFI less than the HUD definition of very low income (less than 50% of the MFI of the City, $35,500);
- Poverty level higher than that of the City (24%);
- Poverty level, excluding students, higher than that of the City (13%),
- Percent of renter-occupied housing units higher than that of the City (52%);
- Percent of <u>homeowners</u> paying more than 30% of their income in housing costs exceeds 50%;

[9] City of Columbia, Missouri. 2015. Strategic Plan 2016-2019. https://www.como.gov/wp-content/uploads/2016-2019-Strategic-Plan.pdf

- Percent of <u>renters</u> paying more than 30% of their income in housing costs exceeds 50%;
- Percent of residents receiving SNAP assistance higher than that of the City (10%); or
- Percent of residents without health insurance less than that of the City (8%).

Using these indicators, the team developed a matrix to assess overall economic stress in the individual tracts (Table 1). Tracts exceeding the indicator thresholds were marked with an "X" and were qualitatively categorized according to potential stress based on the proportion of indicators exceeded (Economic Stress Indicator). Four tracts exceeded more than 80% of the indicators, suggesting a strong potential for economic stress (red). Four tracts exceeded at least 60% of the indicators and (orange) and three tracts exceeded at least 40% of the indicators (yellow), suggesting a moderate and low potential for economic stress. The remaining fourteen tracts do not currently exhibit the potential for economic stress (Attachment B).

Table 1. Summary of Socioeconomic Stress Indicators across Columbia Census Tracts.

Census Tract Number	Percent of Census Tract in City Limits	Below City Median Household Income	Below City Median Family Income	Below HUD Low Income	Below HUD Very Low Income	Above City Poverty Level	Above City Non-Student Poverty Level	Above City Renter Occupied Rate	More than 50% of Home Owners Paying > 30% of Income	More than 50% of Renters Paying > 30%of Income	Above City SNAP Assistance Rate	Below City Health Insurance Coverage Rate	Economic Stress Indicator*
Tract 02	100	x	x	x	x	x	x	x		x	x	x	**0.91**
Tract 03	100	x	**	**	**	x		x		x			**0.36**
Tract 05	100	x	**	**	**	x	x	x		x	x		**0.55**
Tract 06	100									x			**0.09**
Tract 07	100	x	x	x		x	x	x		x	x	x	**0.82**
Tract 09	100	x	x	x	x	x	x	x	x	x	x	x	**1.0**
Tract 10.01	100	x				x		x		x			**0.36**
Tract 10.02	74									x		x	**0.18**
Tract 11.01	65	x	x	x		x	x	x		x		x	**0.73**
Tract 11.03	91												**0.0**
Tract 11.04	57									x			**0.09**
Tract 12.01	100									x		x	**0.18**
Tract 12.02	96												**0.0**
Tract 13	93	x	x	x		x	x	x			x	x	**0.73**
Tract 14	51		x							x	x		**0.27**
Tract 15.02	72	x	x	x		x	x	x			x	x	**0.73**
Tract 15.03	53	x	x	x		x	x			x	x	x	**0.73**
Tract 15.04	94	x	x	x						x	x	x	**0.55**
Tract 16.01	12							x			x	x	**0.27**
Tract 16.02	3		x								x	x	**0.27**
Tract 17.02	1									x			**0.09**
Tract 18.05	11												**0.0**
Tract 21	100	x	x	x	x	x	x	x	x	x	x	x	**1.0**
Tract 22	100	x	**	**	**	x	x	x		x			**0.45**
Columbia (City-Wide)**	NA	x			x								**0.18**

*The Economic Stress Indicator represents the proportion of indicators exceeded in a census tract. Red shading indicates a significant potential for economic stress (indicator > 0.80, or more than 80% of metrics exceeded). Orange shading indicates a moderate potential for economic stress (indicator > 0.60, or 60% of metrics exceeded). Yellow shading indicates a low potential for economic stress (indicator > 0.4, or 40% of metrics exceeded).

**These tracts do not report families.

***Except for the percent of homeowner and renters paying more than 30% of their income in housing costs, the metrics for Columbia were compared to the state of Missouri.

Section 4. Residential Billing Impact Analysis

The socioeconomic review presented in previous sections is valuable because it helps characterize existing conditions and serves as a screening tool for identifying potentially disadvantaged areas in and around the City. These analyses are useful for qualitatively understanding which segments of the community may be impacted by increased wastewater and stormwater service costs, but do not quantify or forecast the magnitude of those impacts. To better understand the extent of potential affordability issues in Columbia, the qualitative socioeconomic review are combined with a quantitative assessment of future financial impacts.

In the context of implementing the IMP, potential financial impacts are measured most directly through an evaluation of existing and anticipated wastewater and stormwater bills. As discussed in Section 1, the current average residential sewer bill in Columbia is approximately $27.50 per month (assuming 5,000 gallons per month consumption). According to the most recent rate survey conducted by the Missouri Public Utilities Alliance (MPUA), Columbia's average sewer bill is lower than most other large cities or sewer districts in Missouri (Figure 4). Although Columbia is one of the few cities in Missouri that has implemented a stormwater tax (average $1.66 per residential user per month), the combined monthly bill for wastewater and stormwater services is still low when compared to the cities referenced in the MPUA survey.

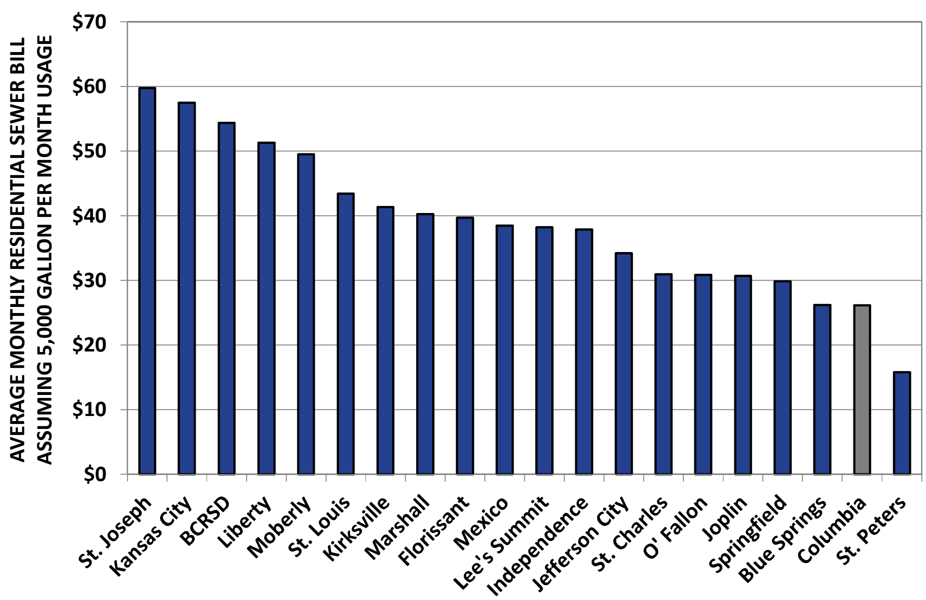

Figure 4. Average Monthly Residential Sewer Bills for Select Missouri Cities. The average monthly bill is calculated assuming 5,000 gallon per month usage.

An important consideration for this affordability evaluation is understanding potential financial impacts that residential ratepayers may experience as the IMP is implemented over time. These impacts are analyzed in the sections that follow.

4.1 IMP Alternatives

As discussed in Technical Memorandum 9, the project team developed suites of wastewater treatment, wastewater collection, and stormwater management alternatives to address system needs, current and anticipated regulatory drivers, and City goals over the next 20 years (the IMP planning period). The alternatives included maintaining existing funding levels or increasing funding to three (Level 1, Level 2, and Level 3) potential higher levels designed to address system needs and goals in an increasingly proactively manner.

Because the City is interested in implementing IMP wastewater and stormwater alternatives that cost-effectively provide the greatest benefit to the community over the 20-year planning period, the project team used a decision analysis tool to identify the funding level that best satisfied that goal. Through that analysis, the team determined that an "Optimized" funding level could be developed by combining the projects that provided the best value from among the four initial funding levels (Table 1).

Table 2. Summary of IMP Alternative Costs and Benefits.

IMP Funding Alternative	20-Year Sewer System Cost (in Millions)	20-Year Stormwater System Cost (in Millions)	Total 20-Year Program Cost (in Millions)	MCDA Incremental Benefit Score
Existing	$488	$70	$558	0.15
Level 1	$803	$163	$966	0.52
Level 2	$893	$237	$1,130	0.79
Level 3	$997	$376	$1,373	0.32
Optimized	**$828**	**$224**	**$1,055**	**0.81**

Before implementing the Optimized alternative, the City must evaluate its impact relative to community affordability and residential monthly bills. To facilitate this analysis, the City applied their existing stormwater and wastewater rate models to forecast future residential user rates based on 20-year cash flows developed for each funding level alternative. Residential bill projections for the existing sewer funding level were calculated assuming rates would increase by 3.1% per year before inflation[10]. For the existing stormwater funding level, bill projections also assume a 3.1% per year average annual increase after the currently scheduled rate increases expire in 2020.

If the City continued funding the Stormwater and Sewer Utilities at existing levels, the average monthly stormwater and sewer bills will increase to $3.80 and $48.51 per month (in 2017 dollars), respectively, by 2036 (Figure 5). Under the three IMP alternatives, average monthly stormwater bills could increase to between $9.12 and $22.51 (in 2017 dollars) and average sewer bills could increase to between $45.46 and $59.90 (in 2017 dollars). The analysis also

[10] According to the National Association of Clean Water Agencies (NACWA) *2016 Cost of Clean Water Index*, the average cost of wastewater services has increased by an average of 3.1% per year before inflation over the last 10 years. The NACWA report may be accessed from http://www.nacwa.org/docs/default-source/news-publications/White-Papers/2017-05-18nacwa_index.pdf?sfvrsn=4

shows that residential stormwater bills for the three IMP alternatives increase at a faster rate than residential sewer bills. This difference is a product of historic underfunding of the stormwater system (see Technical Memoranda 4 and 7) and indicates that relatively more funding is needed to "catch-up" to address stormwater issues.

As noted throughout this memorandum, EPA's 1 to 2% MHI threshold range alone is not a sufficient indicator for characterizing potential financial impacts. However, it does serve as a reasonable starting point for the assessment. The billing analysis shows that the average total monthly sewer and stormwater bill for Levels 3 is above the upper end of this threshold range (2% MHI, see Figure 4 and Attachment C). The average monthly bill in Level 3 also increases at a faster rate during the 20-year planning period than the other alternatives. Together, these results suggest that Level 3 funding is not an affordable alternative. Similarly, average monthly bills for Level 2 (approximately $78) would also exceed the MHI threshold in 2036 (Figure 5). Therefore, it is reasonable to assume that Level 2 is likely not affordable for all segments of the community.

Among the remaining IMP alternatives, the Optimized funding level is preferable because it provides the most overall value to the community (Table 2) and average total monthly bills remain below 2% of MHI throughout the planning period. In the next section, future billing impacts associated with implementing the Optimized funding level are evaluated on a census tract basis to assess the potential geographic distribution of impacts across the City.

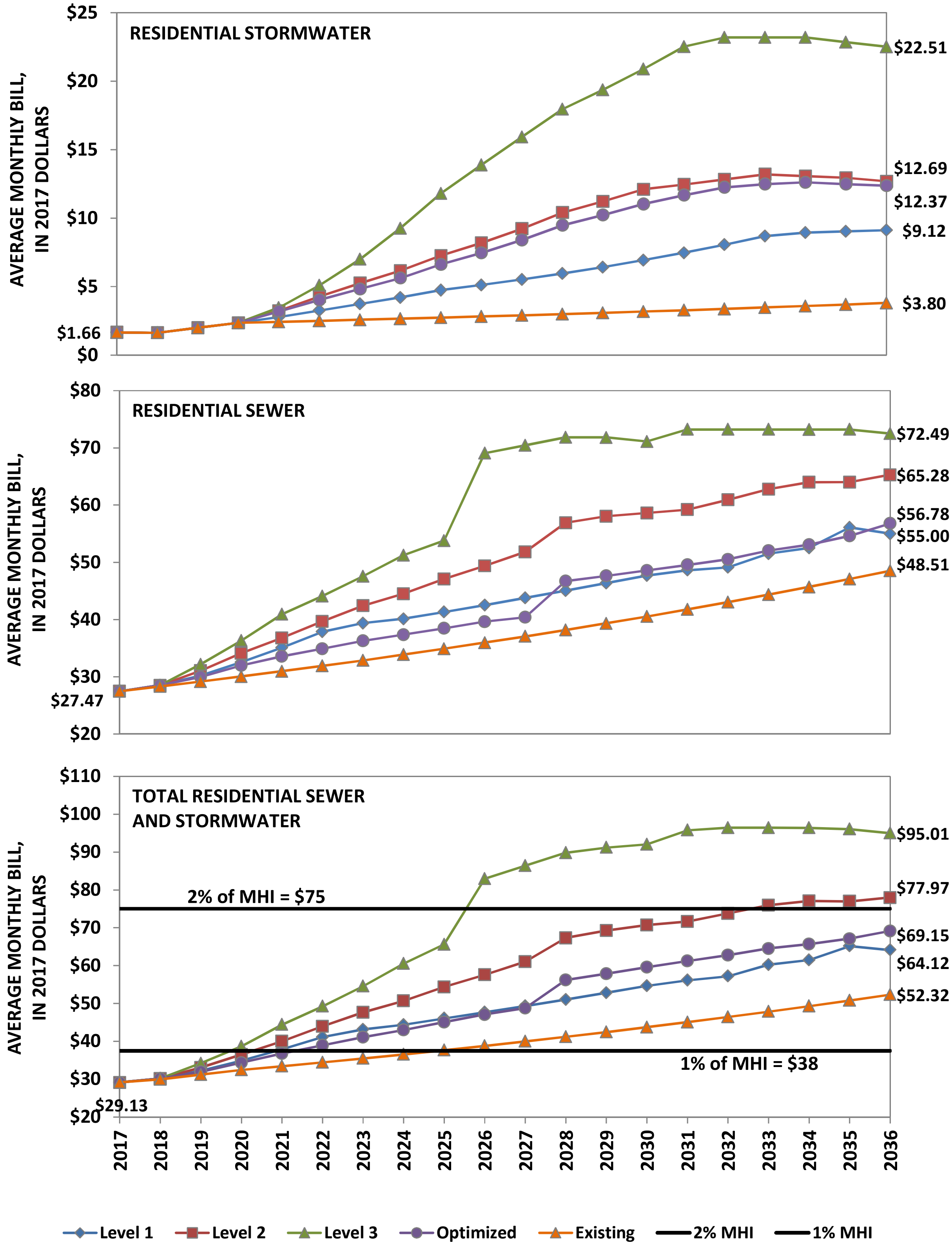

Figure 5. Anticipated Average Monthly Sewer and Stormwater Bills (in 2017 Dollars) for Each of the IMP Alternatives. Sewer bills were calculated assuming 5,000 gallon per month average usage.

4.2 Existing and Projected Billing in Census Tracts

The City provided monthly billing data by account for 2012 through 2014. The residential billing data was aggregated by year for each account to estimate the average monthly sewer bill per census tract. Additionally, the 2017 stormwater rates were used to calculate the average monthly residential stormwater bill per census tract. Collectively, these data represent an estimate of the existing average monthly sewer and stormwater service costs for residential ratepayers in the City based on actual usage (Figure 6).

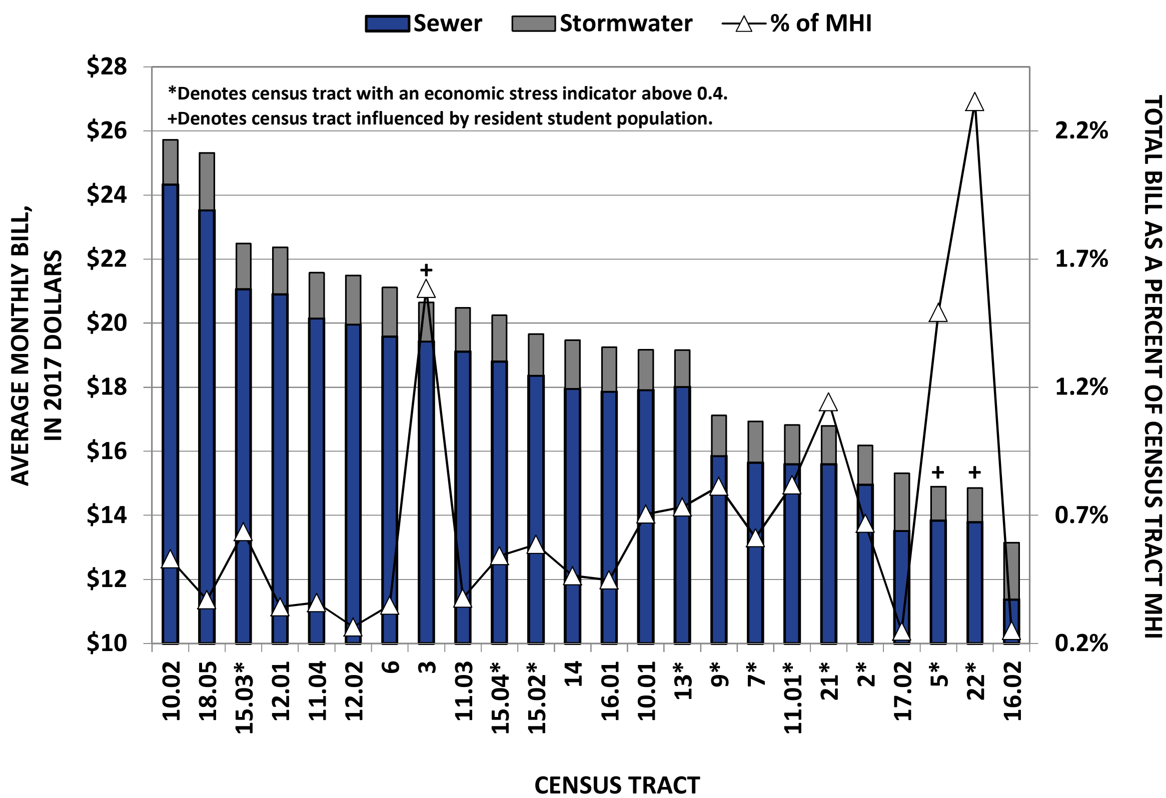

Figure 6. Existing Average Monthly Sewer and Stormwater Bills (in 2017 Dollars) across Columbia Census Tracts. Sewer bills were calculated based on actual usage in each census tract.

Existing total average monthly bills in the census tracts range from approximately $13 to nearly $26 per month, with sewer bills representing the majority of the cost (Figure 6). Only one census tract which is likely heavily influenced by student populations (Tract 22) currently pays more than 2% of their MHI and most tracts currently pay less than 1%. Because residential sewer bills across the City are calculated using the same base and volume charges, the difference in sewer cost between census tracts reflects the difference in actual volume used. These results demonstrate that sewer usage across the City is generally less than the 5,000 gallons per month (equivalent to $27.50 per month) typically assumed for these analyses. Furthermore, the analysis shows that users in economically stressed census tracts use relatively less wastewater services than non-stressed census tracts but pay a higher percentage of their income for those services.

To understand the potential impacts of the Optimized funding level on future bills across the City, average monthly bills were estimated for each census tract at the end of the IMP planning period in 2036. Sewer bills (in 2017 dollars) were estimated by applying the future base and volume rates provided by the City for each IMP alternative to the usage volumes calculated from the 2012 to 2014 sewer bill data. The future stormwater bills were estimated by multiplying the projected Optimized rates (in 2017 dollars) by the existing ratio of average census tract bill to the average city-wide bill.

According to the evaluation, total average bills for the Optimized alternative range from $36 to $61 per month (in 2017 dollars) across census tracts by the end of the 20-year planning period (Figure 7). As with the existing bills, census tracts with the highest percentage of economic stress indicators tend to have lower bills but pay a higher percent of their MHI. The analysis also shows that six census tracts could pay at least 2% of their MHI, but three of those (Tracts 3, 5, and 22) are heavily influenced by the student population.

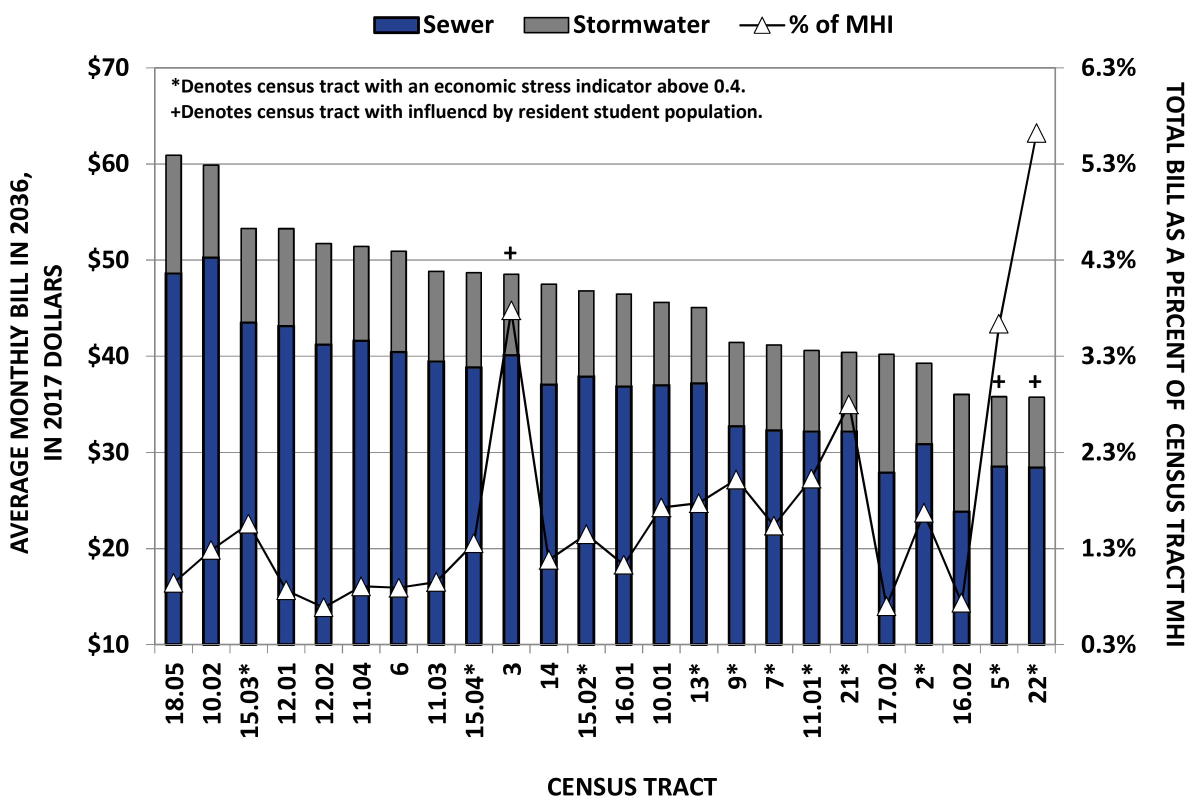

Figure 7. Future Average Monthly Sewer and Stormwater Bills (in 2017 Dollars) across Census Tracts that Result from Implementing the Optimized Alternative. Sewer bills were calculated based on actual usage in each census tract.

4.3 Residential Affordability Analysis

To characterize the extent of potential residential affordability issues associated with implementing the Optimized IMP alternative, results of the qualitative socioeconomic review (Table 1) were combined with the quantitative assessment of future billing impacts (Figure 5). This analysis includes comparison of the projected 2036 residential bill as a percent of projected MHI (assuming a 2% annual increase) in each census tract to the economic stress indicator in each tract.

The analysis assumes that 2% of MHI (EPA's suggested threshold) and 0.6 economic stress indicator (from Table 1) are appropriate thresholds for identifying potentially impacted census tracts. Using these thresholds, census tracts that will pay less than 2% of MHI and have less an economic stress indicator below 0.6 (Quadrant I) are expected to have a low potential to experience affordability impacts (Figure 8). Conversely, census tracts that will pay more than 2% of MHI and have an economic stress indicators above 0.6 (Quadrant IV) are expected to have a high potential to experience affordability impacts. Census tracts that exceed either the MHI (Quadrant II) or economic stress (Quadrant III) threshold are expected to have a moderate potential to experience impacts.

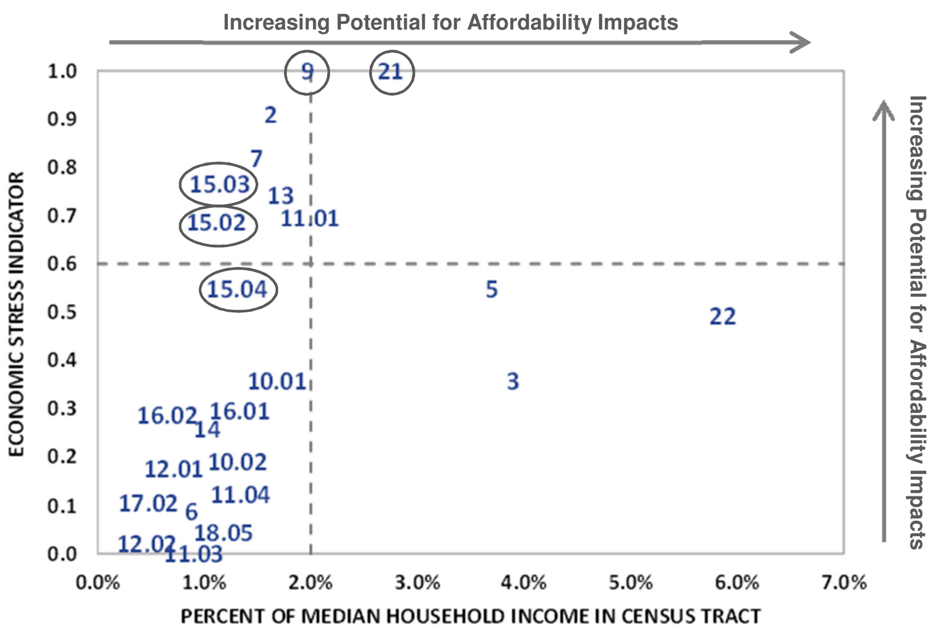

Figure 8. Evaluation of the Potential for Affordability Impacts across Columbia Census Tracts during the 20-Year IMP Planning Period. The numbers in the graph represent the census tract identification number. Circles around the numbers indicate that the census tract includes one of the three social equity neighborhoods identified in the Strategic Plan. The analysis excludes census tracts most heavily influenced by the resident student population (Tracts 3, 5, and 22).

Results of the analysis demonstrate that 12 of the census tracts (Quadrant I) are not expected to experience significant affordability issues over the IMP planning period as a result of implementing the Optimized alternative (Figure 8). Of the remaining tracts, nine equal or exceed at least one of the evaluation thresholds (Quadrants II and III) and three (Quadrant IV) equal or exceed both thresholds. Two of the census tracts in Quadrant IV (9 and 21) include the entire central neighborhood identified in the Strategic Plan.

Although the three census tracts (9, 11.01, and 21) in Quadrant IV may have significant potential to face affordability impacts, average total monthly bills will increase gradually and will not approach potentially unaffordable level of 2% MHI until 2028 (Tract 21, Figure 9). It is also important to note that the forecasted billing impacts presented here are currently based on planning level cost estimates and must be reevaluated as the City gathers additional data during IMP implementation. As part of the IMP implementation process, City plans to reevaluate regulatory requirements and refine projected sewer and stormwater program needs, costs, and bill impacts every 5 to 10 years.

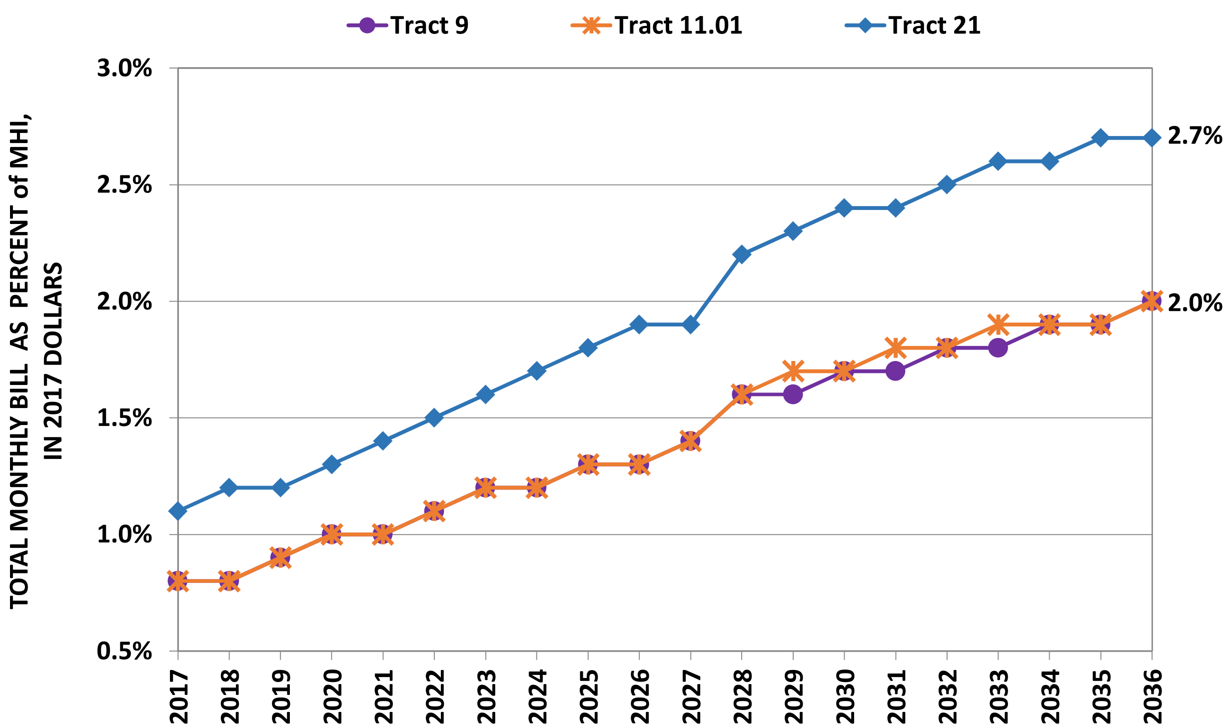

Figure 9. Future Average Total Monthly Bills (in 2017 Dollars) as a Percentage of Median Household Income in Census Tracts with the Greatest Potential to Experience Affordability Impacts.

Section 5. Summary

As part of the IMP process, the City and their project team identified a series of potential wastewater treatment, wastewater collection, and stormwater system alternatives to address infrastructure and environmental needs that are important to Columbia residents. The purpose of this memorandum was to evaluate and identify potential affordability issues that could result from implementing those alternatives.

The IMP affordability evaluation included a review of both the overall existing socioeconomic conditions in the City and potential future financial impacts related to increased wastewater and stormwater service costs. The evaluation was structured such that it incorporates elements of the City's most recent Strategic Plan, which identified improving social equity as one of the top five priorities over the next three years. Results of the evaluation are summarized below.

- **Overall Socioeconomic Conditions –** The project team found that resident college students skew results of important socioeconomic metrics such as population, poverty levels, and income. When metrics are corrected to account for the students, overall socioeconomic conditions in the City are generally strong. However, there are disadvantaged segments of the community which warrant additional consideration. More specifically, the project team evaluated economic stress indicators across the 25 census tracts in the City and found that four tracts, primarily located in central Columbia, exhibited a strong potential for economic stress (Table 1). Seven other tracts exhibited a low to moderate potential for economic stress.

- **Residential Billing Impacts –** The project team developed suites of wastewater treatment, wastewater collection, and stormwater management alternatives to address system needs, current and anticipated regulatory drivers, and City goals over the next 20 years. The alternatives included maintaining existing funding levels, increasing funding to three (Levels 1, 2, and 3) potential higher levels designed to address system needs and goals in an increasingly proactively manner, or implementing an Optimized alternative. The City applied their existing stormwater and wastewater rate models to forecast future residential user rates and bills based on 20-year cash flows developed for each funding level alternative. Rate structures were maintained at current base and volume charge ratios for rate and bill forecasting. Analysis of the resulting average monthly bills indicated that the Optimized funding level is the preferred alternative since it provides the most overall value to the community. Under the Optimized alternative, average community-wide stormwater and sewer bills would increase to approximately $12 and $46 dollars per month (in 2017 dollars), respectively by 2036.

Results from the socioeconomic and residential billing impact evaluation were combined into an overall affordability analysis to characterize the spatial extent of potential economic impacts and affordability issues associated with implementing the Optimized IMP alternative. The analysis indicated that three census tracts have significant potential to experience affordability issues by the end of the planning period in 2036, with two of those three tracts being located within the central neighborhood identified in the City's Strategic Plan.

Over the next 10 years however, average total monthly bills in those tracts will increase gradually and will not approach potentially unaffordable levels until 2028. Because the forecasted impacts presented here are currently based on planning level cost estimates, they will likely change as the City gathers additional during IMP implementation. Additionally, changes in regulatory requirements, program needs, or socioeconomic conditions across the City may also influence future affordability projections. Therefore, the City understands that it will be important to refine projected sewer and stormwater program needs, costs, and bill impacts every 5 to 10 years during IMP implementation.

Results of the affordability and socioeconomic evaluation suggest that the Optimized alternative will be affordable to residential ratepayers over the first 10 years of IMP implementation. The City should therefore move forward with implementing the Optimized alternative while also gathering the information and data needed to refine cost estimates and billing impact projections in the next 10 years. To that end, the City should prepare a 5-year plan that outlines initial IMP projects that will be pursued to develop the information and data necessary to refine program needs, costs, and billing impacts over the remainder of the IMP planning period.

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Attachment A

Columbia Census Tracts

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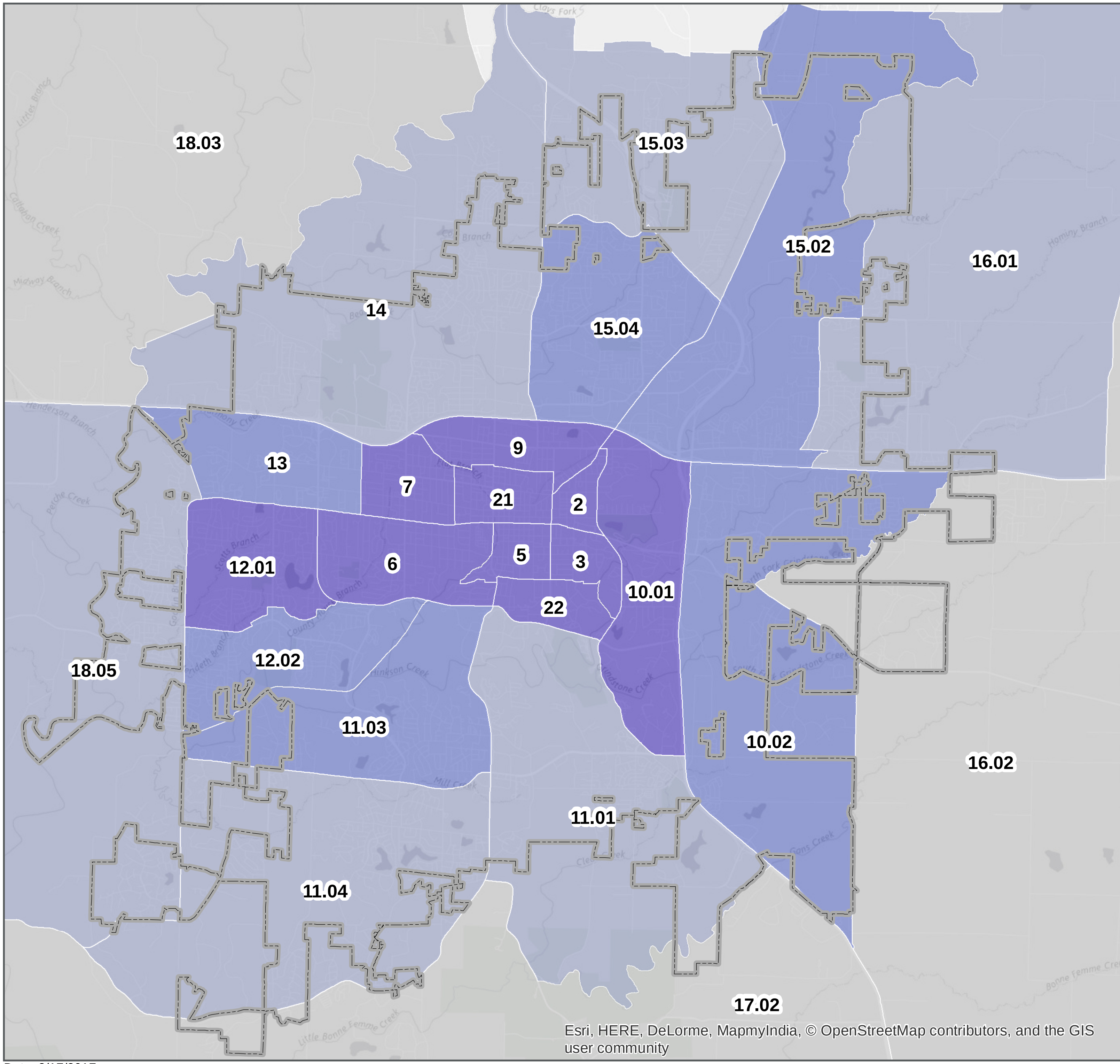

Our Columbia Waters
Integrated Management Plan
Wastewater & Stormwater

LEGEND

- In City limits
- Primarily in City
- City border
- Primarily outside City

Tract	Percent Within City
2	100%
3	100%
5	100%
6	100%
7	100%
9	100%
10.01	100%
10.02	74%
11.01	65%
11.03	91%
11.04	57%
12.01	100%
12.02	96%

Tract	Percent Within City
13	93%
14	51%
15.02	72%
15.03	53%
15.04	94%
16.01	12%
16.02	3%
17.02	1%
18.03	0.01%
18.05	11%
21	100%
22	100%

CENSUS TRACTS

CITY OF COLUMBIA MISSOURI

WASTEWATER & STORMWATER INTEGRATED MANAGEMENT PLAN

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Attachment B

Census Tract Economic Stress Indicator Scores

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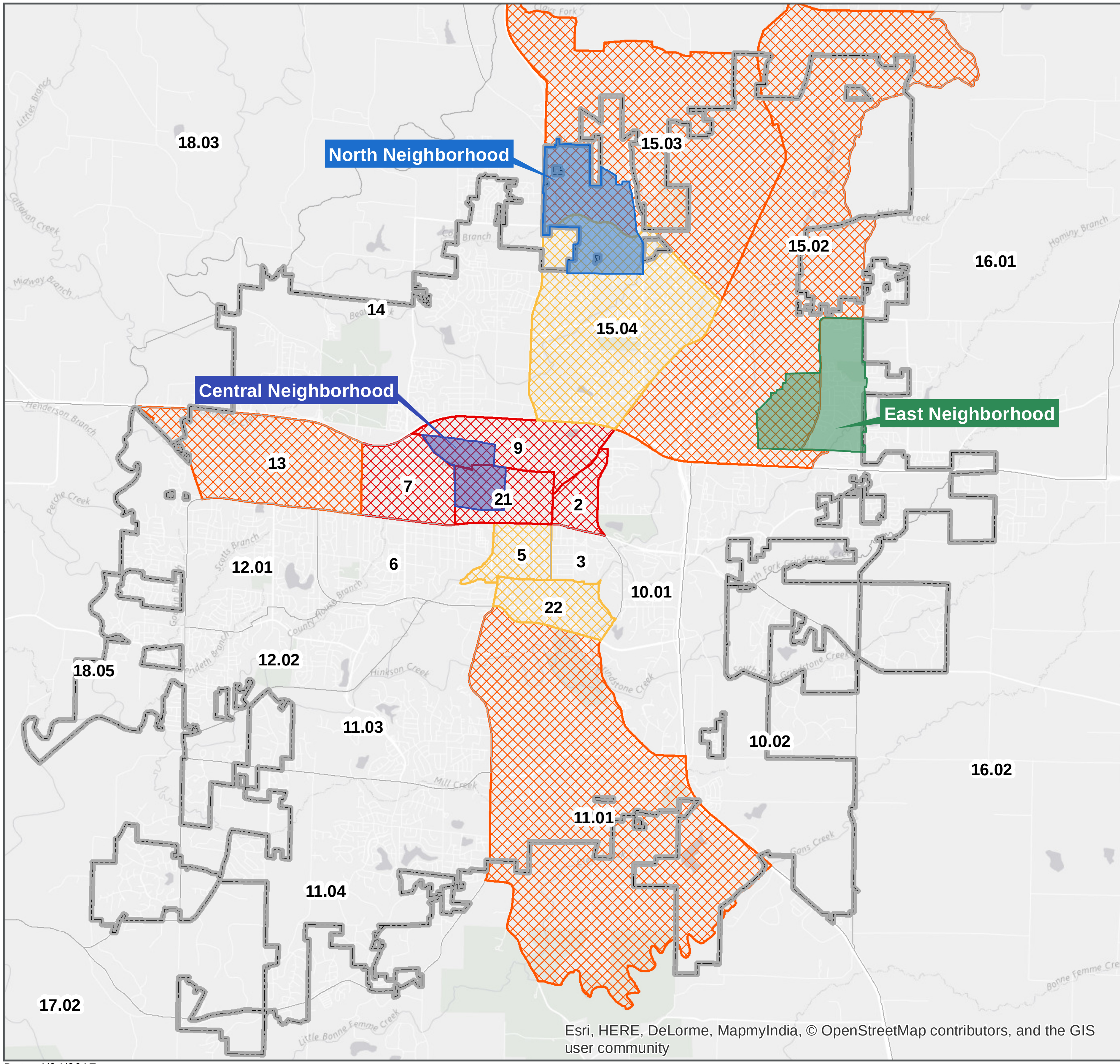

Our Columbia Waters
Integrated Management Plan
Wastewater & Stormwater

LEGEND

Economic Metrics

- < 40%
- 40 - 60%
- 60 - 80%
- > 80%

Tract	Percent Within City
2	100%
3	100%
5	100%
6	100%
7	100%
9	100%
10.01	100%
10.02	74%
11.01	65%
11.03	91%
11.04	57%
12.01	100%
12.02	96%

Tract	Percent Within City
13	93%
14	51%
15.02	72%
15.03	53%
15.04	94%
16.01	12%
16.02	3%
17.02	1%
18.03	0.01%
18.05	11%
21	100%
22	100%

ECONOMIC METRICS CENSUS TRACTS

CITY OF COLUMBIA MISSOURI

WASTEWATER & STORMWATER INTEGRATED MANAGEMENT PLAN

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Technical Memorandum 10

Attachment C

Residential Bill Projections

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Attachment C. Residential Bill Projections.

Attachment C.1. Projected Average Monthly Sewer (assuming 5,000 gallons) and Stormwater Bills (in 2017 Dollars) for Each of the IMP Alternatives.

Year	Residential Sewer					Residential Stormwater					Total Residential Sewer and Stormwater				
	Existing	Level 1	Level 2	Level 3	Optimized	Existing	Level 1	Level 2	Level 3	Optimized	Existing	Level 1	Level 2	Level 3	Optimized
2017	$27.47	$27.47	$27.47	$27.47	$27.47	$1.66	$1.66	$1.66	$1.66	$1.66	$29.13	$29.13	$29.13	$29.13	$29.13
2018	$28.30	$28.52	$28.52	$28.52	$28.52	$1.63	$1.63	$1.63	$1.63	$1.63	$29.93	$30.15	$30.15	$30.15	$30.15
2019	$29.16	$30.19	$31.06	$32.17	$29.95	$2.00	$2.00	$2.00	$2.00	$2.00	$31.16	$32.19	$33.06	$34.17	$31.95
2020	$30.05	$32.54	$34.13	$36.30	$31.98	$2.36	$2.36	$2.36	$2.36	$2.36	$32.41	$34.90	$36.48	$38.66	$34.34
2021	$30.96	$35.11	$36.78	$40.92	$33.58	$2.43	$2.77	$3.23	$3.46	$3.19	$33.39	$37.88	$40.01	$44.39	$36.76
2022	$31.90	$37.87	$39.70	$44.11	$34.90	$2.50	$3.26	$4.28	$5.10	$4.03	$34.40	$41.13	$43.98	$49.21	$38.93
2023	$32.87	$39.37	$42.41	$47.55	$36.27	$2.58	$3.74	$5.25	$7.00	$4.82	$35.45	$43.11	$47.66	$54.55	$41.09
2024	$33.87	$40.12	$44.49	$51.26	$37.35	$2.66	$4.21	$6.17	$9.26	$5.62	$36.53	$44.34	$50.67	$60.52	$42.97
2025	$34.90	$41.31	$47.09	$53.79	$38.47	$2.74	$4.75	$7.26	$11.81	$6.62	$37.64	$46.06	$54.35	$65.60	$45.09
2026	$35.96	$42.52	$49.37	$69.07	$39.63	$2.82	$5.12	$8.19	$13.89	$7.46	$38.78	$47.65	$57.56	$82.96	$47.09
2027	$37.06	$43.77	$51.81	$70.44	$40.39	$2.91	$5.52	$9.23	$15.93	$8.41	$39.96	$49.30	$61.04	$86.37	$48.80
2028	$38.18	$45.05	$56.90	$71.84	$46.73	$2.99	$5.96	$10.41	$17.96	$9.48	$41.18	$51.01	$67.31	$89.80	$56.21
2029	$39.34	$46.36	$58.04	$71.81	$47.64	$3.08	$6.43	$11.22	$19.37	$10.23	$42.43	$52.79	$69.27	$91.18	$57.86
2030	$40.54	$47.71	$58.61	$71.11	$48.58	$3.18	$6.93	$12.10	$20.89	$11.03	$43.72	$54.64	$70.71	$92.00	$59.60
2031	$41.77	$48.62	$59.20	$73.21	$49.54	$3.27	$7.47	$12.46	$22.53	$11.68	$45.04	$56.10	$71.66	$95.74	$61.22
2032	$43.04	$49.12	$60.94	$73.23	$50.53	$3.37	$8.06	$12.83	$23.19	$12.25	$46.41	$57.17	$73.77	$96.42	$62.78
2033	$44.35	$51.52	$62.76	$73.22	$52.04	$3.48	$8.69	$13.20	$23.19	$12.49	$47.82	$60.21	$75.97	$96.41	$64.53
2034	$45.70	$52.51	$64.00	$73.20	$53.07	$3.58	$8.95	$13.07	$23.19	$12.61	$49.28	$61.45	$77.07	$96.40	$65.68
2035	$47.08	$56.10	$64.02	$73.21	$54.62	$3.69	$9.03	$12.95	$22.85	$12.49	$50.78	$65.13	$76.96	$96.06	$67.11
2036	$48.51	$55.00	$65.28	$72.49	$56.78	$3.80	$9.12	$12.69	$22.51	$12.37	$52.32	$64.12	$77.97	$95.01	$69.15