Local Government Program • Department of Political Science

A Review of Municipal Asset Management Plans for Stormwater Asset Management Program in Selected Single-Tier Municipalities in Ontario: The successful implementation of O.Reg. 588/17.

Subject Keywords: Asset Management Plan (AMP), Stormwater, Municipalities, Public Administration, Local Government, O.Reg. 588/17, Infrastructure

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MPA Research Report

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Abstract

The emergence of the asset management plan (AMP) as a mandatory regulatory requirement for municipalities in Ontario has garnered substantial attention to facilitate comprehensive planning of municipal infrastructure assets and long-term financial strategizing. Municipalities' primary goal is to ensure dependable stormwater services to residents and businesses while promoting economic vibrancy, reconciling social and environmental objectives, upholding the stormwater infrastructure to ensure efficient wet weather flow, and proficient flood risk management.

The study aims to explore the intricacies of stormwater asset management plan, assess the existing challenges and alignment to Ontario Regulation 588/17 concerning asset management planning for municipal infrastructure, with a specific focus on stormwater infrastructure in selected Ontario single-tier municipalities, and underscore the significance of this issue. The study will delve into a comparative analysis of the asset management plans of three single-tier municipalities, serving as a case study, and propose pragmatic and actionable recommendations. These recommendations seek to aid other Canadian cities and prospective studies in attaining municipal short-, medium-, and long-term objectives for sustainable asset delivery. By employing qualitative research and document analysis strategies, the assessment of municipally owned stormwater infrastructure conditions will facilitate the identification of empirical evidence and the development of informed solutions, thereby empowering municipal decision-makers.

While the foundation for developing Asset Management Plans (AMPs) for stormwater assets is rapidly progressing, municipalities may enhance their data collection efforts to operate and maintain infrastructures at acceptable service levels. Furthermore, including this information in the AMP is crucial for future asset lifecycle planning.

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As an ardent philomath, I ventured into this program to bridge my knowledge gap in Canadian local government and public administration while seeking personal growth. "The process of learning has no end," and this resonates deeply with my educational philosophy, underscoring the significance of lifelong learning.

Throughout this academic odyssey, I have been enriched with invaluable theoretical and practical knowledge through interactions with esteemed professors, engaged classmates, and a supportive network of friends and colleagues, both locally and globally. My heartfelt gratitude and appreciation go to everyone who has contributed to my growth and learning. A special acknowledgment is extended to my parents and parents-in-law, whose unwavering prayers and support have been a pillar of strength for my family and me. I am especially indebted to my mother-in-law for her unwavering emotional support to my wife and me and her dedicated care for our son during my absence. I express the immeasurable impact their support has had on my journey.

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Chapter 1 – Introduction

Every level of government must urgently implement proactive and organized strategies for overseeing infrastructure assets in modern society. Canadian Municipalities provide critical infrastructure to their communities and businesses and are financially maintained through continuous asset investment planning using user fees, grants, and the tax base. Approximately 70% of the core assets are maintained and operated by Municipalities. (CIRC, 2019). However, assets are deteriorating rapidly and aging faster than expected due to rapid growth and performance demand, causing a funding gap in many Canadian municipalities. In the context of municipal assets, a funding gap occurs when the infrastructure capital is lower than required to maintain the asset at the current level of service, often leading to an asset investment deficit.

Canada faces a pressing issue with numerous municipal infrastructures classified as 'fair' or 'very poor' conditions. There is an urgent need for infrastructure-based rehabilitation and replacement within the next 10-20 years to uphold or enhance the level of service (LoS) (CIRC, 2019). Approximately 40-60% of stormwater infrastructure is assessed to be in good or very good condition. Many stormwater assets are still undergoing evaluation as historical data collection has been neglected. Most stormwater management assets were built in the last 20 years, and there is a growing focus on understanding their future requirements for rehabilitation or replacement (CIRC, 2019). As an illustration, when stormwater runoff flows through storm ditches and drains without treatment, it can gather various pollutants like pesticides and bacteria and then deposit them into aquatic environments such as rivers, streams, and oceans.

Considering the impacts of climate change, it is essential to have a thorough grasp of the current state of stormwater infrastructure. Local authorities play a crucial role in supervising stormwater drainage, constructing infrastructure that can withstand

flooding, and ensuring adherence to a wide range of environmental, economic, and public safety standards and regulations set forth by higher levels of government. The municipal asset management planning and policies specified in Ontario regulation (O. Reg.) 588/17 will be rolled out gradually over five years (Ontario Government, 2021). Successful asset management (AM) is driven by asset value and lifecycle management, which ensure long-term affordability, manage risks, evaluate performance, and coordinate technical and financial plans. By embracing a comprehensive approach to managing infrastructure and adhering to a transparent regulatory framework, municipalities can demonstrate enormous dedication to environmental, social, and economic accountability, ultimately delivering substantial benefits to society and reassuring stakeholders about the system's fairness.

It is essential to remember that stormwater assets are considered core assets for municipalities in Ontario, according to Ontario Regulation 588/17, which pertains to asset management planning for municipal infrastructure. Core infrastructures, such as stormwater, roads, water, wastewater, and bridges, play a crucial role in modern society, impacting daily living standards, economic prosperity, and environmental well-being and safety. Stormwater assets encompass the collection, transmission, treatment, retention, infiltration, control, or disposal of stormwater runoff from surface groundwater, heavy snowfalls, or rain. (Ontario Government, 2021). Water-related assets, including water, wastewater, and stormwater, are critical due to their significant threat to human existence and their substantial financial, environmental, and public health impact when they fail.

Given the situation's urgency, municipalities must adopt a proactive approach to infrastructure planning. They are responsible for the ownership and operation of various infrastructure assets and must engage in long-range asset and infrastructure planning. This involves using evidence-based asset conditions and data assessment

to understand the likelihood of failure and develop financial strategies for asset renewal, rehabilitation, or replacement as these assets age.

As Canada experiences a significant increase in population, the municipalities where newcomers are settling face the challenge of improving and expanding infrastructure performance and capacity to sustain service levels. Despite efforts to upgrade infrastructure, many municipal infrastructure assets are aging, with most acquired more than 40-60 years ago. Consequently, these assets fail frequently, leading to municipalities implementing reactive maintenance plans due to limited resources and funding. The 2019 Canadian Infrastructure Report Card highlighted this issue, revealing that most core assets are in poor-to-very-poor condition, with approximately 30% being stormwater, water, and wastewater assets (CIRC, 2019).

The state of core public infrastructure across Canada was evaluated by the Canadian Infrastructure Report Card (CIRC) through a voluntary survey submitted by municipalities to assess the national infrastructure benchmark. As the 2019 CIRC report card indicates, a significant portion of national assets will need rehabilitation or replacement in the next 5-10 years, as the Canadian Core Public Infrastructure Survey (CCPIS) revealed. However, this presents an opportunity for significant improvement and growth. As a result, numerous local governments aim to understand the state of their long-term infrastructure and how well it matches the funding gap and reinvestment requirements by utilizing Asset Management Plans (AMP). The CCPIS utilized a condition rating scale that includes categories such as very poor, poor, fair, good, and very good, as well as unknown conditions, which aligns with the industry's best practices (CIRC, 2019). Maintenance and the operations of municipal infrastructure systems and planning for critical asset replacement and rehabilitation projects require significant funding, yet it is the biggest barrier to many municipalities. However, having enough funding sources (such as water rates, development charges,

reserve funds for long-term financial planning, grants, loans, public-private partnerships, etc.) can improve the overall condition of municipal infrastructure systems (Doumani et al., 2006). Although Canada does not currently enforce standards for asset management planning, Ontario has regulated it, and other provinces and territories are considering the benefits of having a similar, consistent regulation for municipal asset management. Investing in municipal infrastructure will address the current challenges, strengthen and stimulate the economy, create pathways for jobs, increase the quality of life, and build strong communities across Canada. The Ministry of Infrastructure, a key player in this process, recognizes that municipalities, provinces, and federal governments require more work to address municipal infrastructure challenges. All levels of government, including local municipalities, are committed to developing a robust municipal infrastructure through the "Building Together guide as a foundation for Asset Management Strategy," which will allow for infrastructure planning prioritization over a need-based approach (Building Together Guide, 2016).

Public infrastructure is crucial in enhancing the quality of life and contributing to Canadian municipalities' economic prosperity. Ontario made an essential move in June 2011 with the introduction of the *Building Together guide* and toolkit, a comprehensive infrastructure plan for Ontario. This guideline aims to support and assist municipal officials in grasping the significance and characteristics of an asset management plan, promoting standardization and consistency in municipal asset management, utilizing a wide range of infrastructure financing tools effectively, and ensuring responsible asset management. *Building Together* guide addresses the broader trends impacting Ontario's infrastructure requirements, such as a more global and service-oriented economy, ageing assets, rapid urbanization, population growth, and the impacts of a changing climate (Ontario Government, 2021). On June 4th,

2015, the Infrastructure for Jobs and Prosperity Act was implemented. This act is a significant step towards promoting evidence-based, strategic, and ethical long-term infrastructure planning. It facilitates job creation, training opportunities, economic growth, and environmental conservation. Additionally, it emphasized the integration of design excellence into infrastructure planning (Infrastructure for Jobs and Prosperity Act, 2015, S.O. 2015, c. 15, 2022). The act required local municipalities to support empirically based asset planning. It mandated all municipalities to develop an asset management plan outlining infrastructure status, asset risks, conditions, age, and inventory, meeting the prescribed regulatory standards and to be submitted to the Province of Ontario (Ontario Government, 2021).

In 2017, the government of Ontario introduced Ontario Regulation 588/17: Asset Management Planning for Municipal Infrastructure, allowing municipalities to take a multi-year approach to plan for the maintenance and improvement of their infrastructure assets. Beginning on January 1, 2018, the Province of Ontario implemented this regulation, requiring municipalities to develop a strategic asset management policy (SAMP) and an asset management plan (AMP) for their infrastructure under the oversight of municipal councils. Ontario Regulation 588/17 outlines specific guidelines for gradually implementing municipal asset management plans and policies over five years (Ontario Government, 2021).

Table 1: Asset Management Plan Timeline - By O. Reg. 588/17

July 1, 2019	A Strategic Asset Management Policy (SAMP) must articulate specific principles and commitments to guide decisions around when, why, and how money is spent on infrastructure systems.
July 1, 2022	An Asset Management Plan is required that documents the current Levels of Service being provided and the costs to sustain them for the 'core' assets per O. Reg. 588/17.
July 1, 2024	An Asset Management Plan is required that documents the current Levels of Service being provided and the costs to sustain them for all

	infrastructure systems (non-core and core assets).
July 1, 2025	An Asset Management Plan is required for all infrastructure systems. It must document the current Levels of Service being provided, the costs to sustain them, the desired Levels of Service, the costs to achieve them, and the financial strategy to fund the necessary expenditures.
Section 7. (1) of the Ontario regulation 588/17 requires Asset Management Plans to be reviewed every five years by municipalities. Additionally, each Asset Management Plan must be made accessible to the public by posting online.	

(Ontario Government, 2021)

Water, Wastewater, and Stormwater assets are classified as core infrastructure under Ontario Regulation 588/18 (O.Reg. 588/17). Asset management planning for stormwater infrastructure is a reasonably new approach because most Ontario municipalities still struggle to gather relevant data on stormwater assets. Although there has been limited scholarly research on asset management planning, the topic and Ontario regulation on municipal asset planning are largely still in the infancy of planning stormwater infrastructure. Stormwater management plays a crucial role in rural areas, especially urban infrastructure in heavily populated areas and is essential for preserving community resilience, public health, and environmental sustainability. Stormwater infrastructure management presents significant challenges for municipalities in Ontario, not only because of the rapid exacerbation of urbanization or population but also because of aging infrastructure and the increasing impacts of climate change. Municipalities need to plan for efficient asset management to overcome these challenges, enabling them to optimize investments, enhance operational efficiency, and ensure the long-term reliability of their infrastructure systems.

Typically, Stormwater infrastructure has an average expected useful life of 80 years (Statistics Canada, 2022). Stormwater management generally controls and guides water flow from impermeable surfaces such as parking lots, rooftops, snow melts, and roadways to prevent erosion, flooding, and water quality degradation in

nearby water sources (Setoodeh, 2024). However, concerns arise due to the aging of current infrastructure, including increased maintenance costs, service interruptions, and vulnerability to extreme weather. These issues underscore the immediate need for governments to adopt proactive asset management approaches that integrate legislative frameworks and technological advancements to enhance infrastructure performance and sustainability (El-Diraby et al., 2017).

This study aims to evaluate the current state of asset management plans in selected Ontario municipalities, using stormwater assets as a case study and the Ontario Guideline (O.Reg. 588/17) requirements as grading criteria. This research aims to examine and evaluate the methods employed by the selected Ontario municipalities in developing and implementing stormwater asset management plans. The goal is to pinpoint the gaps, challenges, and advantages of stormwater management practices among municipalities by assessing how much these plans comply with Ontario regulation 588/17. This assessment is intended to facilitate well-informed decision-making for local governments and policymakers, future academic research, and sustainable development efforts within Ontario's municipal sector, contributing to a more profound comprehension and application of urban stormwater management (Harvey, 2015). The research focuses on single-tier municipalities in Ontario that have already released core asset management plans before the deadline of June 1, 2022, as stipulated by the Ontario Region. The research aims to address the following questions:

- ✓ What methods do municipalities in Ontario use to develop stormwater asset management plans?
    - The goal is to identify the approach and methods selected municipalities in Ontario use to evaluate and manage their stormwater asset inventories.

- ✓ Does the Municipal Asset Management plan for stormwater Asset Management Inventory in Ontario reflect the O. Reg. 588/17 requirement?
    - The aim is to evaluate selected Ontario municipalities' stormwater asset management plans using O.Reg. 588/17 as grading criteria.

The selected Ontario municipalities will be benchmarked based on how they have reported on the O. Reg 588/18 requirements and deliverables for stormwater asset planning, such as asset inventory reporting, infrastructure current levels of service (LoS), risk assessment, financial strategies, and condition assessment. The research used a web-based randomization selection process (n=3) based on the availability of asset management plans (AMPs) and the population size of single-tier municipalities. The analysis includes reviewing these local municipalities' stormwater asset management plans.

In conclusion, the resilience of urban development, improved environmental sustainability, alarming population growth, and risk reduction related to aging infrastructure all depend on efficient infrastructure, including stormwater assets in Ontario municipalities. This study/review will provide insights for future scholarly research and offer recommendations to guide future policy development, enhance infrastructure design, and support long-term sustainability in stormwater management throughout Ontario by analyzing current practices and regulatory frameworks.

1.1 Research Aim & Questions

- ✓ What methods do municipalities in Ontario use to develop stormwater asset management plans?
    - The primary goal of this research is to understand the various

approaches and methods employed by municipalities in Ontario to create their stormwater asset management plans. The focus is identifying the strategies, tools, and processes selected local governments use to evaluate, prioritize, and oversee their stormwater infrastructure. By exploring these methods, the study aims to offer insights into the most effective practices, innovations, and challenges encountered in stormwater asset management among selected municipalities.

- ✓ The goal is to identify the approach and methods selected municipalities in Ontario use to evaluate and manage their stormwater asset inventories.
    - The goal of this research is to examine and document the methods and approaches used by municipalities in Ontario to evaluate and oversee their stormwater asset inventory. Stormwater management aims to comprehensively comprehend how municipalities conduct AMPs, documenting municipal asset inventories, condition assessments, risk analyses, and lifecycle planning. Through identifying these approaches, the study seeks to highlight innovations, challenges, and optimal practices that facilitate effective stormwater asset management.

- ✓ Does the Municipal Asset Management plan for stormwater Asset Management Inventory in Ontario reflect the O. Reg. 588/17 requirement?
    - This study is significant as it assesses how Ontario municipalities' asset management plans (AMPs) comply with the regulatory framework outlined in Ontario Regulation 588/17 (O.Reg. 588/17). The research examines the reported asset inventories, condition assessments, risk

management, lifecycle planning, and financial sustainability in the selected municipalities AMPs as mandated by the regulation. Evaluating compliance levels identifies areas for enhancement, policy ramifications, and stormwater asset management planning deficiencies.

- ✓ The aim is to evaluate selected Ontario municipalities' stormwater asset management plans using O.Reg. 588/17 as grading criteria.
    - This research is a comprehensive assessment of the level of adherence of stormwater asset management plans in Ontario municipalities to the criteria specified in O.Reg. 588/17. We will conduct a thorough review of AMPs to determine how well they align with regulatory standards in terms of thoroughness, accuracy, and effectiveness in accomplishing the objectives of sustainable infrastructure management. Through evaluating compliance, the research aims to highlight the potential advantages, drawbacks, and areas requiring enhancement in municipalities' stormwater asset management approaches, providing prospects for more efficient and sustainable management.

Chapter 2: Literature Review

Municipal organizations' work maintaining old and new infrastructure cannot be understated; however, the importance and worth of local infrastructure extend past the benefits of providing services and can be seen as crucial to the fundamental assets we depend on daily. The study will draw upon municipal asset management plan reports, publicly available strategic and operational documents, Ontario regulation 588/17, asset management standards and guidelines, and select scholarly research materials focusing on infrastructure asset management planning.

The following literature review sections will delve into best practices in asset management planning, clarify critical terms, and highlight significant findings, explicitly focusing on stormwater asset management planning. This literature review aims to provide a comprehensive understanding of the current state of stormwater asset management planning, which will inform the subsequent evaluation of Ontario municipalities' AMPs.

A Framework for Delivering Sustainable Asset Services.

The asset management (AM) framework outlines a structured approach to help local governments achieve service, asset, and financial sustainability through different implementation methods. The asset management process comprises numerous components, and the framework offers a continuous circular pathway to interconnect them all. Instead of dictating specific methodologies, the AM framework concentrates on desired outcomes, enabling local governments to devise and implement an approach that can be gradually implemented and tailored to meet each local government's unique needs and capabilities. Moreover, the framework mirrors current best practices and conforms to globally accepted ones, such as the International Infrastructure Management Manual (IIMM) and the ISO 55000 standard for Asset Management (ISO 55000:2014, 2014).

Sustainable Service Delivery is essential for meeting current community service needs and ensuring that these services are delivered socially, economically, and environmentally responsibly for the needs of current and future generations. Communities construct and uphold infrastructure to offer services that enhance our quality of life, safeguard our health and safety, and advance social, economic, and environmental well-being. Neglecting the upkeep of our infrastructure, mismanaging our natural resources, and failing to safeguard the benefits provided by nature may pose the risk of deteriorating or losing the services enjoyed by communities on which future generations may depend. However, solid asset management practices contribute to the sustainable delivery of services by considering community needs and comprehending the balance between available resources and desired services. People, information, assets, and finances are essential components of the asset management framework, and their integration throughout the asset management process is crucial for successful service delivery (AMBC, 2022).

The asset management plan must include the following elements to ensure that asset management is aligned with the highest industry norms.

- **Asset Management Strategy** (this involves developing various asset lifecycle strategies for operating and maintaining the asset)
- **State of Infrastructure** (ask questions on what the municipalities own and where they are, what conditions they are, and understanding the estimated useful life)
- **Risk Management** (this involves understanding the asset risks, mitigation plans, and impact of asset failure to the Municipalities)
- **Levels of Service** (current and proposed, involves understanding service level drivers and impact due to population growth, demand analysis, etc.).
- **Financial Strategy** (this involves understanding the current funding level and implementing a long-term financial plan to maintain and sustain service levels.

Asset Management Planning

Municipal asset management planning responds to concerns regarding asset condition, deterioration, and performance over time (McBean & Schuster, 2008). Many large and small municipalities require assistance making optimal decisions concerning infrastructure planning and policies, especially considering shortages of asset management professionals and a need for increased funding and resources proportional to the population.

Local governments are critical in overseeing and upholding their infrastructure assets to promote economic growth and well-being within their communities. Each local government actively determines the necessary infrastructure assets to provide services and establishes suitable and feasible service standards. These needs influence decisions regarding the allocation of funds for infrastructure, as well as the desires and objectives of local communities and their capacity to cover the expenses of these services. This accountability is upheld through the councils responsible to the citizens (AMO, 2021). The International Organization for Standardization (ISO) for asset management overview, principles, and terminologies introduced asset management standards (ISO 55000 series, i.e., ISO 55000; ISO 55001, ISO55002) that are internationally recognized and globally accepted. These standards, introduced in 2014, define assets as items, things, or entities with potential or actual value to an organization. Asset management ensures that these assets continue to provide services that contribute to our quality of life by being effectively maintained and utilized. Asset management entails the coordinated activity of an organization to realize value from assets, involving a systematic process of operating, maintaining, upgrading, and disposing of assets cost-effectively (ISO 55000:2014, 2014).

As outlined in O.Reg. 588/17, asset management involves the planning for municipal infrastructure and making optimized decisions about infrastructure assets,

including acquisition, operation, maintenance, renewal, replacement, and disposal (Ontario Government, 2021). The strategic asset management plan document for the selected Ontario municipalities should align with industry best practices and global asset management standards and comply with O.Reg. 588/17, establishing a clear link between capital/operating investments and other municipal strategic priorities.

Asset Management Plan (AMP)

The Asset Management Plan (AMP) is a comprehensive strategic document developed by private organizations or municipalities to guide the management of infrastructure assets. Municipal assets, such as roads, bridges, water systems, stormwater, public buildings, and parks, are essential services that require efficient maintenance and management to support economic growth and provide reliable services to the community. The AMP is designed to align with municipal strategic priorities and ensure a comparative level of asset management practice across all municipal services. Drawing from best practices in asset management and adhering to Ontario Regulation 588/17, the AMP provides a detailed framework for the sustainable management of municipal infrastructure. This regulation mandates that municipalities have asset management plans to improve practices and ensure infrastructure sustainability.

Critical aspects of the AMP encompass service reliability, cost efficiency, risk management, strategic planning, and regulatory compliance. These aspects ensure the delivery of essential services, timely maintenance and renewal of assets, identification and mitigation of risks, alignment with long-term strategic goals, and compliance with provincial regulations. Critical components of the AMP include asset inventory, condition assessment, lifecycle strategies, risk management, financial planning, climate change adaptation, data management, and continuous improvement. These components provide a detailed listing of assets inventory,

evaluate asset conditions, develop strategies for maintaining and replacing assets, prioritize investments based on risk assessments, outline costs and funding strategies for asset management, incorporate resilience measures against extreme weather, enhance asset data quality, and emphasize ongoing improvements and technology integration.

Asset Management Plan (AMP) in Canada and Ontario

Canada's asset management field is still developing, with the capacity for asset management steadily growing. The state of Canada's infrastructure is supported by findings from the voluntary Canadian Core Public Infrastructure Survey (CCPIS) conducted on the federal level. The data gathered from the CCPIS serves as the fundamental basis for evaluating the performance of Canada's public infrastructure. The Canadian Core Public Infrastructure Survey (CCPIS) results highlight the increasing adoption of asset management (AM) practices in larger municipalities while stressing the ongoing necessity of offering support, including financial and technical assistance, to smaller municipalities for implementing AM practices.

The disparity in adopting documented Asset Management Plans (AMP) based on population size was evident in the survey results. Only 29% of municipalities with less than 5,000 people reported having a documented AMP, whereas 56% of those with a population of 5,000 - 30,000 and 70% of large cities with over 30,000 reported having a documented AMP. According to the CIRC report, around 40% of municipal wastewater and stormwater assets are in good or very good condition. Nonetheless, accessibility and historical data issues have led to a substantial portion of the data on the condition of wastewater and stormwater assets being unknown (CIRC, 2019).

Municipalities are working hard to create an asset management plan (AMP) to understand better the overall state of their infrastructure and how it matches funding needs and reinvestment requirements. However, overcoming the resistance to

introducing an organizational change approach to asset management planning has been challenging. The significance of infrastructure assets cannot be overstated, especially given limited budgets and tax revenues. Experts in the municipal industry stress the need for increased investment to maintain service levels and address the mounting backlog of infrastructure needs. The adverse impact of the infrastructure deficit on service levels should be noticed. Without augmented investment, assets will deteriorate over time, and the backlog of infrastructure needs will become overwhelming. According to (Wiebe, 2012), the Federation of Canadian Municipalities (FCM) has determined that Canada's municipal infrastructure deficit stands at $123 billion for existing assets and an additional $115 billion for new infrastructure needs. The total deficit escalates to nearly $400 billion when considering federal and provincial infrastructure upgrades, stressing the urgency for immediate and decisive action. To maintain the effective operation of essential and critical services infrastructure, Canada must show financial stability in its water, wastewater, stormwater management, and other fundamental and non-fundamental assets. Municipalities must find ways to enhance services with limited budgets, which can be challenging, mainly when aiming to uphold crucial high-performing assets that provide substantial value to the community (FCM, 2003).

Over the past decade, Ontario Municipalities have made significant strides in ensuring the sustainability of asset management planning and processes. This began with provincial governments collaborating with the federal government and local municipalities to allocate and distribute funds, such as federal gas tax funds and the newly named Canada Communities Building Fund (CCBF, 2023). Furthermore, the implemented process integrates asset management planning with any financial plans about water, wastewater, and stormwater assets, leading to enhanced asset management practices across Ontario. An example of this is the connection of asset

management practices to the *Safe Water Drinking Act in the O.Reg. 588/17.* Despite this progress in Ontario municipalities, there is still a need for more robust infrastructure management strategies and improved inspection methods to ensure that these assets can handle the challenges posed by aging infrastructure, population growth, and the increased demand for infrastructure investment and maintenance (OSWCA, 2018).

When a core asset like stormwater infrastructure fails, it can significantly impact lives and harm the environment. Some consequences of such an effect are drinking water contamination, sewer and water backup dampening properties, flooding, and environmental damage to wildlife and the green environment (OSWCA, 2018). In many Ontario municipalities, infrastructure decisions have historically relied on age-based condition data. However, this approach carries significant risks, as it may lead to inaccurate condition forecasts and misallocating funding for asset replacement. The use of well-established asset management (AM) procedures for condition assessments is relatively new in Canada, including in Ontario, where the implementation of scientific techniques and validated protocols outlined in Ontario regulation 588/17(O.Reg. 588/17) is still in its early stages. The requirement for consistent use of empirical methods for condition assessment under O. Reg 588/17 is an area that requires more attention. This research will examine the practices in selected Ontario municipalities for stormwater asset classes to better understand the practice's comparison.

Frameworks for Policies and Regulations

Ontario Regulation (O.Reg. 588/17) and Asset Management Plans and Policy

Adopting Ontario Regulation 588/17 was a crucial milestone in establishing guidelines for asset management planning for Ontario municipalities under the Infrastructure for Jobs and Prosperity Act of 2015. Published on December 27, 2017,

O. Reg. 588/17 aimed to standardize asset management planning for municipal assets, presenting opportunities for enhanced long-term financial planning and decision-making. It also aimed to satisfy the eligibility criteria for senior government funding across municipalities in Ontario. Nevertheless, numerous municipalities, particularly smaller ones, require additional resources, training, and expertise in asset management planning. Although larger municipalities with multiple funding sources have embraced the regulations, a noticeable gap must be addressed in supporting asset planning and policy development, particularly for smaller municipalities needing extra resources (Infrastructure for Jobs and Prosperity Act, 2015, S.O. 2015, c. 15, 2022).

In addition, O. Reg 588/17 includes coordinating financial strategies for the municipality's water assets concerning the ***Safe Drinking Water Act 2002.*** It also involves alignment with Ontario's land-use planning framework and relevant policy statements of the *Planning Act* (Ontario Government, 2021). Because municipalities have various responsibilities in providing services to their communities, it is essential to further connect this regulation to other relevant policies that can improve the overall efficiency of local municipalities. This includes integrating asset management into infrastructure development processes, environmental initiatives, climate change strategies, conservation efforts, and energy demand management. Moreover, the regulation specifies demands for a comprehensive asset management strategy, encompassing both qualitative and quantitative explanations of technical and customer service levels, performance indicators for individual asset types, asset lifecycle activities, existing and projected asset service levels, and a financial plan detailing short, medium, and long-term economic strategies spanning a decade.

Table 2: Stormwater infrastructure levels of service requirements in Ontario Regulation 588:17.

STORMWATER MANAGEMENT ASSETS

Column 1 Service attribute	Column 2 Community levels of service (qualitative descriptions)	Column 3 Technical levels of service (technical metrics)
Scope	Description, which may include maps, of the user groups or areas of the municipality that are protected from flooding, including the extent of the protection provided by the municipal stormwater management system.	1. Percentage of properties in municipality resilient to a 100-year storm. 2. Percentage of the municipal stormwater management system resilient to a 5-year storm.

(Ontario Government, 2021)

In addition, municipalities must create a strategic asset management policy (SAMP) to direct their asset management activities and initiatives. This policy needs to be approved by the Council. Additionally, the regulation specifies that the asset management plan (AMP) must undergo an annual review and be revised every five years. These mandates are crucial for ensuring efficient asset management practices and promoting the long-term sustainability of Ontario municipalities.

Ontario Regulation 588/17 Function on Stormwater Assets

To comply with Regulation 588/17, municipalities must develop comprehensive asset management plans (AMPs) incorporating stormwater assets (Ontario Government, 2021). FCM indicates that the legislation outlines specific criteria for long-term planning, asset inventories, condition assessments, risk management strategies, and financial viability (FCM, 2003). Adhering to O.Reg. 588/17 supports efficient infrastructure decision-making and environmental stewardship by enhancing accountability, transparency, and regulatory consistency in stormwater management practices (Ontario Government, 2021).

Obstacles to Regulatory Compliance

Municipalities struggle to achieve complete compliance despite the benefits of regulatory frameworks like O.Reg. 588/17. Implementation challenges may arise from staff expertise and understanding of the policy, limited resources, and evolving regulatory interpretations. To fully realize the benefits of stormwater management regulations and address these challenges, it is essential to effectively engage several interest groups and build capacity through continuous training.

Asset Lifecycle Cost Analysis

When evaluating stormwater infrastructure investments, conducting a thorough analysis of lifecycle costs is essential to ensure long-term financial sustainability. This assessment involves examining the costs associated with asset replacement, repairs, and maintenance, enabling municipalities to develop financial plans that support the resilience and affordability of their infrastructure (Johnson D. , 2019). Lifecycle cost analysis considers inflation, environmental impacts, and asset depreciation. This approach provides decision-makers, i.e., the Municipal Council, with data-driven insights to prioritize infrastructure investments and optimize budget allocation. This strategy promotes sustainable asset management practices by balancing immediate operational needs and long-term infrastructure planning objectives (Johnson D. , 2019).

Stormwater Program and Asset Management Application

Various challenges include aging infrastructure, stricter stormwater quality regulations, flood risk management, water supply reliability, and budgetary and workforce constraints. These challenges highlight the importance of implementing a new approach to stormwater management to improve business practices. By incorporating essential asset management procedures, stormwater managers can thoroughly understand their assets, determine their lifespan, assess necessary

investments, and evaluate related business risks. Municipalities across Ontario and Canada require the benefits of a Watershed Asset Management Plan, as it provides organizations with essential information to make well-informed, timely, cost-effective, and well-justified decisions.

Stormwater Asset Management

Why Is Stormwater Management Important?

Stormwater management is critical in urban sustainability, as it addresses challenges like flood control, water quality enhancement, and environmental conservation. Managing stormwater infrastructure involves meticulous planning, maintenance, and adaptation strategies to mitigate risks associated with urban development and the impacts of climate change. Urban areas need infrastructure capable of efficiently collecting, conveying, and treating stormwater to combat environmental degradation and safeguard public health, given the significant runoff from impermeable surfaces in these regions. Municipalities employ various methods to regulate stormwater runoff and enhance urban resilience, including subsurface storage systems, retention ponds, and green infrastructure.

GIS Technology Utilization to Manage Stormwater Infrastructure.

Geographic Information Systems (GIS) integrate geographical data to support well-informed decision-making and operational efficiency. Municipalities utilize GIS to map their stormwater infrastructure, assess the condition of their assets, establish maintenance priorities, and allocate resources efficiently through spatial analysis (Johnson D. , 2019). For instance, GIS applications offer real-time monitoring of stormwater systems, predictive modelling of flood hazards, and visualization of infrastructure performance metrics to enhance overall management effectiveness. This integration of technology helps municipalities adopt proactive approaches to infrastructure development and climate adaptation (Johnson D. , 2019).

Stormwater Asset Management Challenges

Municipalities encounter challenges such as limited funding, lack of data, and the intricate nature of urban sprawling environments despite technological advancements and regulatory frameworks. These challenges may hinder the effective management of stormwater assets, leading to delays in infrastructure upgrades, heightened operational costs, and increased vulnerability to the impacts of climate change. To tackle these issues, it is imperative to emphasize stakeholder engagement (with residents, businesses, institutions, and upper levels of government or non-governmental organizations), data-informed decision-making, and adaptive management approaches. By overcoming these barriers and enhancing the quality of the environment and the community's well-being, municipalities can improve the sustainability and resilience of stormwater infrastructure.

Stormwater Management Best Practices and Innovations

New approaches like community-based stormwater management, intelligent technology integration, and green infrastructure use are becoming recognized as effective methods in urban stormwater management. When handling stormwater resources, these approaches emphasize community resilience, biodiversity conservation, and sustainable development principles. For example, permeable pavements, rain gardens, and green roofs reduce stormwater runoff, enhancing urban beauty and water quality. According to (Ditaranto, 2023), integrating these advancements into municipal planning frameworks can assist in achieving climate adaptation goals, mitigating the impact of urban heat islands, and improving ecological services in urban areas.

New Developments in Stormwater Management

Collaborative Approaches within the Community

To address urban water challenges, local communities, municipalities, and businesses collaborate on community-based projects for managing stormwater. These initiatives prioritize community resilience and ownership of stormwater solutions by focusing on outreach, education, and involving the community in decision-making processes. Municipalities can enhance the sustainability and effectiveness of projects by engaging stakeholders in the planning and implementation stages.

Utilization of Advanced Technology

Integrating intelligent technologies into stormwater management enhances data-driven decision-making and operational efficiency. (Johnson D. , 2019). According to Baird, 2011, by employing sensors, real-time monitoring systems, and predictive analytics, cities can monitor stormwater flows, detect irregularities, and proactively respond to weather events. This approach leverages technology, minimizes environmental impact, reduces maintenance costs, and improves infrastructure performance. (Johnson D. , 2019).

Eco-Friendly Building Materials

(Setoodeh, 2024) states that incorporating green infrastructure is crucial for sustainable stormwater management as it mimics natural hydrological processes. Approaches such as rain gardens, permeable pavement, and green roofs enhance water quality and reduce runoff volumes, as highlighted in (Setoodeh, 2024) study. These nature-based solutions support biodiversity, enhance urban aesthetics, and mitigate the impact of the urban heat island, improving overall community well-being.

Climate Change Adaptation & Stormwater Management

In the face of ongoing climate change, it is crucial to acknowledge its potential effects on the management and maintenance of stormwater systems. When planning to manage assets, climate change acts as both a catalyst and a risk factor. Consequently, local governments must create plans that address both the reduction and adaptation to climate change as a part of their overall strategy to decrease emissions and promote a commitment to sustainability and resilience. This approach will enable municipalities to uphold their mission of delivering essential services to the community and align with their environmental leadership objective by ensuring public infrastructure protection.

Green Infrastructure's Environmental Benefits

Green infrastructure, beyond its stormwater management role, offers a host of significant environmental benefits. For instance, urban forests and green roofs are crucial in mitigating air pollution, sequestering carbon dioxide, and providing habitats for wildlife. Wetlands and bioretention basins, on the other hand, purify stormwater pollutants and nutrients, enhancing water quality in downstream water bodies. Given its diverse advantages, green infrastructure is not just a component but a driving force in urban planning strategies to bolster environmental sustainability. It inspires urban planners and policymakers to consider the potential for a greener future.

Financial Aspects of Stormwater Management

The Economic Viability of Green Infrastructure

Research has shown that green infrastructure solutions are often more cost-effective than traditional grey infrastructure options. While the initial installation costs may be higher, the long-term savings in maintenance and operational expenses, along with the social benefits like improved public health and reduced flood damage,

make the initial investment in green infrastructure a financially sound decision. Municipalities can assess the financial viability of green infrastructure through lifecycle cost analysis and integrate them into comprehensive plans for asset management. (Johnson D. , 2019).

Financial Strategies and Funding Mechanisms

Stormwater management programs often struggle to secure sufficient funding. Municipalities typically rely on various financing sources, such as public-private partnerships, utility rates, and government grants, to support infrastructure improvements. (Johnson D. , 2019) It underscores that financial strategies that set condition assessments, risk management, and long-term planning are crucial for ensuring the sustainability of stormwater infrastructure investments. (Graham, 2021) Suggests that municipalities can enhance resource allocation and build resilience in stormwater management by aligning financial planning with community priorities and regulatory requirements, providing a sense of reassurance about the future of stormwater management.

Literature Review in Summary

The literature review examines how stormwater management is evolving, emphasizing the integration of advanced techniques, emerging technologies, and legal frameworks. Integrating intelligent technologies, environmentally friendly infrastructure solutions, and community-driven approaches can improve urban resilience and sustainability. Economic considerations, such as lifecycle cost evaluations and funding sources, underscore the importance of financial planning in achieving long-term infrastructure objectives. This emphasis on financial planning should instill confidence in the audience about the project's feasibility. Policies like O.Reg. 588/17 and others are vital in standardizing asset planning processes and promoting environmental stewardship in Ontario municipalities for stormwater assets. The comprehensive

foundation provided by this literature review synthesis will advance strategies for managing stormwater assets and facilitate developing working policies for stormwater management evidence by consolidating existing knowledge and best practices; this project aims to contribute to sustainable infrastructure solutions that benefit communities and enhance environmental quality across Ontario.

Chapter 3: Methodology

Research Method & Design

This research delves into the practices of stormwater asset management in Ontario municipalities using a qualitative research design. This design is chosen because it can conduct comprehensive investigations, unravel complex phenomena, and capture diverse viewpoints and experiences. (Creswell, 2013). Qualitative research can explore the processes, regulatory compliance, and challenges encountered in the creation, execution, and adherence to stormwater asset management plans in municipalities. (Creswell, 2013). According to (Patton, 2015), this method allows for a more nuanced understanding of the variables affecting decision-making procedures and the effectiveness of asset management techniques in different urban contexts. Prior research entailed examining the publicly available documents of the municipalities to comprehend the stormwater asset management planning procedures as per the requirements of O.Reg. 588/17 listed in Table 1. O.Reg. 588/17 mandates that municipalities must have core asset management plans in place by July 1, 2022, including stormwater asset management.

Single Tier Municipalities

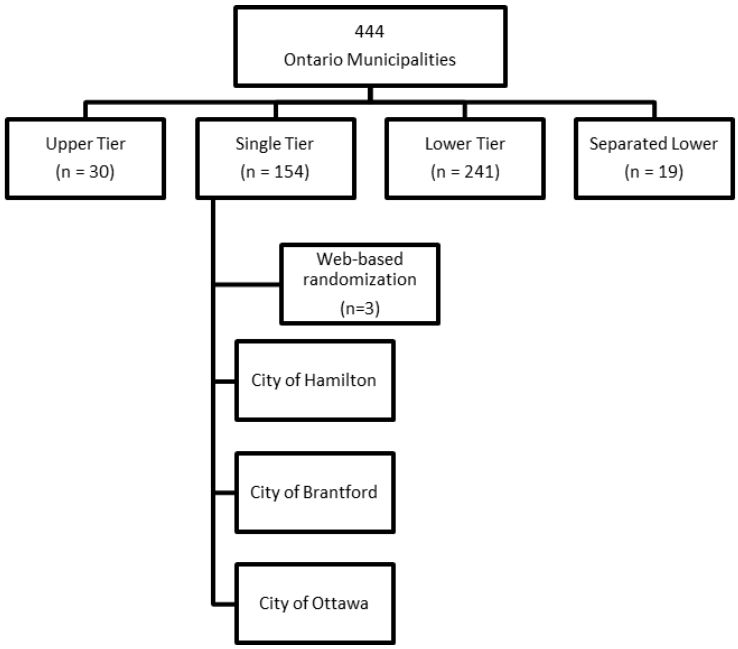
In Ontario, single-tier municipalities include separated municipalities within a county but operate independently from the county for municipal purposes. This group also includes northern municipalities that do not have higher-level governance at the district level. Additionally, former county or regional municipalities consolidated into single-tier municipalities are part of this category. Single-tier municipalities are accountable for delivering all local services to their residents (AMO, 2021)

Sampling Technique

The sampling strategy involves selecting single-tier municipalities in Ontario with a population of over 25,000. This population threshold indicates larger urban areas that encounter significant challenges in managing stormwater. (Yin, 2018) Recommends using a stratified random sampling approach to ensure diverse geographic representation across different locations in Ontario. This method focuses on a specific group of municipalities to capture a variety of stormwater management techniques, levels of regulatory compliance, and infrastructure challenges.

To address the research question, the single-tier municipalities in Ontario will be stratified into small (<25,000 population) and large municipalities (> 25,000) as defined by O. Reg. guidelines. The study is limited to single-tier municipalities because they are responsible for providing all residents' services. The selection process will involve simple randomization to choose three municipalities from Ontario's total 444 municipalities based on the population size of single-tier municipalities for the study. The study examined the Municipalities of Hamilton, Brantford, and Ottawa through case studies. These municipalities were chosen randomly from a group of single-tier municipalities in Ontario. They were selected because they had complete and publicly available core stormwater reporting in their asset management plans, meeting the requirements for the core asset submission. Due by July 1st, 2022, as outlined in O.Reg. 588/17 timeline - see Table 1

Figure 1: Selection Process of Ontario Single-Tier Municipalities



Document Analysis

A comprehensive document analysis methodology was employed to address our research inquiries, allowing for the thorough evaluation of each case and facilitating comparisons between all three cases. The asset management plans for the selected municipalities were acquired from publicly accessible online sources. The analysis will meticulously scrutinize the provincial guidelines delineated in Ontario Regulation 588/17: Asset Management Planning for Municipal Infrastructure and reference internationally recognized asset management standards or practices outlined in ISO 55000. These standards encompass various facets such as infrastructure condition, risk management, service level, asset strategy, and financial strategy. The document analysis will primarily focus on the section of stormwater assets outlined in the asset management plans, encapsulating the four categories specified in the Ontario Guidelines: state of infrastructure, levels of service, asset management strategy, and finance strategy.

The online collection of asset management plans from publicly available sources will focus on each chosen municipality. Specifically, the analysis will center on the provincial guidelines outlined in Ontario Regulation 588/17 on asset management planning for municipal infrastructure.

Data Collection

This study's primary data collection method is the comprehensive analysis of Municipal Asset Management Plans (AMPs) from 2017 to 2022. The data extracted from these AMPs represents more than just a compilation of numerical data and statistical figures; it embodies a repository of invaluable insights awaiting discovery. To ensure a meticulous and dependable collection of AMPs, diverse sources such as municipal websites, open records, and direct access to municipalities' open-source resources and document libraries will be utilized. This comprehensive approach to data collection is paramount for systematically evaluating and interpreting planning strategies, performance indicators, and regulatory compliance. The information gleaned from asset inventory techniques, condition assessment procedures, risk management plans, lifecycle planning frameworks, and financial sustainability metrics outlined in each AMP is indispensable for this study.

Data Interpretation

Thematic analysis in data interpretation aims to uncover trends, patterns, and themes in selected municipalities' stormwater asset management methods (Braun & Clarke, 2013). The grading criteria to assess compliance with O.Reg. 588/17 are as follows: Grade A (80-100%), Grade B (60-79%), Grade C (40-59%), Grade D (20-39%), and Grade E (0-19%). The data extracted from AMPs will support the thematic analysis, facilitating the recognition of strengths, weaknesses, and areas requiring enhancement in stormwater asset management practices (Braun & Clarke, 2013). By synthesizing the results, this study seeks to understand the present status of

stormwater management and adherence to regulatory frameworks in Ontario municipalities.

Case Studies Selection

The Cities of Hamilton, Brantford, and Ottawa were selected for detailed case studies. The selection criteria consider factors such as population size, availability of AM planning resources, and accessibility of comprehensive AMPs. Case studies provide extensive insights into the strategies, challenges, and outcomes of stormwater asset management at the municipal level, allowing for comparative research and the determination of best practices. (Yin, 2018). Each case study will thoroughly examine AMPs to assess infrastructure conditions, risks, and management approaches.

Research Limitations, Inclusion, and Exclusion

Some of the research study's limitations include inadequate detail in the Asset Management Plans (AMPs), primarily designed for municipal independent reporting and purposes other than research. Furthermore, document analysis as a qualitative research method may not consistently furnish the requisite detail to address the research question, necessitating ongoing supplementary research to gather comprehensive insights. Given the substantial number of municipalities in Ontario, conducting an extensive study of all municipal asset management plans may not be feasible. Therefore, the sample size may not effectively represent the entire population of Ontario. Other limitations include operationalizing the variables, time constraints, inconsistent results, varied interpretations of asset strategies, levels of service (LoS), and insufficient literature on asset management planning, evaluation, and success measures.

Inclusion Criteria:

- Single-tier Municipalities
- AMP Compliance with O.Reg. (Core Assets)
- Available Electronic Asset Management Plan (2017 – 2022 O.Reg. Core Assets Requirement)

Rationale for inclusion

- Single-tier municipalities have responsibilities for all local services to their residents.
- A single-tier municipality does not form part of an upper-tier municipality for municipal purposes.

Exclusion Criteria

- Upper tier, lower tier, separated lower tier Municipalities.
- Municipalities with no online AMP

Ontario Regulation 588/17 Guidelines and Requirements for Asset Management Planning for Municipal Infrastructure

Figures 2 and 3 below show the Ontario regulation 588/17 guidelines for comparing stormwater asset management plans by the three selected randomized municipalities.

Figure 2: O.Reg. 588/17 Requirement Guidelines

ASSET MANAGEMENT PLANS

Asset management plans, current levels of service

5. (1) Every municipality shall prepare an asset management plan in respect of its core municipal infrastructure assets on or before July 1, 2022, and in respect of all of its other municipal infrastructure assets on or before July 1, 2024. O. Reg. 193/21, s. 1.

(2) A municipality's asset management plan must include the following:

1. For each asset category, the current levels of service being provided, determined in accordance with the following qualitative descriptions and technical metrics and based on data from at most the two calendar years prior to the year in which all information required under this section is included in the asset management plan:
    i. With respect to core municipal infrastructure assets, the qualitative descriptions set out in Column 2 and the technical metrics set out in Column 3 of Table 1, 2, 3, 4 or 5, as the case may be.
    ii. With respect to all other municipal infrastructure assets, the qualitative descriptions and technical metrics established by the municipality.
2. The current performance of each asset category, determined in accordance with the performance measures established by the municipality, such as those that would measure energy usage and operating efficiency, and based on data from at most two calendar years prior to the year in which all information required under this section is included in the asset management plan.
3. For each asset category,
    i. a summary of the assets in the category,
    ii. the replacement cost of the assets in the category,
    iii. the average age of the assets in the category, determined by assessing the average age of the components of the assets,
    iv. the information available on the condition of the assets in the category, and
    v. a description of the municipality's approach to assessing the condition of the assets in the category, based on recognized and generally accepted good engineering practices where appropriate.
4. For each asset category, the lifecycle activities that would need to be undertaken to maintain the current levels of service as described in paragraph 1 for each of the 10 years following the year for which the current levels of service under paragraph 1 are determined and the costs of providing those activities based on an assessment of the following:
    i. The full lifecycle of the assets.
    ii. The options for which lifecycle activities could potentially be undertaken to maintain the current levels of service.
    iii. The risks associated with the options referred to in subparagraph ii.
    iv. The lifecycle activities referred to in subparagraph ii that can be undertaken for the lowest cost to maintain the current levels of service.
5. For municipalities with a population of less than 25,000, as reported by Statistics Canada in the most recent official census, the following:
    i. A description of assumptions regarding future changes in population or economic activity.
    ii. How the assumptions referred to in subparagraph i relate to the information required by paragraph 4.

Figure 3: O.Reg. 588/17 Requirement Guidelines (continued)

5. For municipalities with a population of less than 25,000, as reported by Statistics Canada in the most recent official census, the following:
    i. A description of assumptions regarding future changes in population or economic activity.
    ii. How the assumptions referred to in subparagraph i relate to the information required by paragraph 4.
6. For municipalities with a population of 25,000 or more, as reported by Statistics Canada in the most recent official census, the following:
    i. With respect to municipalities in the Greater Golden Horseshoe growth plan area, if the population and employment forecasts for the municipality are set out in Schedule 3 or 7 to the 2017 Growth Plan, those forecasts.
    ii. With respect to lower-tier municipalities in the Greater Golden Horseshoe growth plan area, if the population and employment forecasts for the municipality are not set out in Schedule 7 to the 2017 Growth Plan, the portion of the forecasts allocated to the lower-tier municipality in the official plan of the upper-tier municipality of which it is a part.
    iii. With respect to upper-tier municipalities or single-tier municipalities outside of the Greater Golden Horseshoe growth plan area, the population and employment forecasts for the municipality that are set out in its official plan.
    iv. With respect to lower-tier municipalities outside of the Greater Golden Horseshoe growth plan area, the population and employment forecasts for the lower-tier municipality that are set out in the official plan of the upper-tier municipality of which it is a part.
    v. If, with respect to any municipality referred to in subparagraph iii or iv, the population and employment forecasts for the municipality cannot be determined as set out in those subparagraphs, a description of assumptions regarding future changes in population or economic activity.
    vi. For each of the 10 years following the year for which the current levels of service under paragraph 1 are determined, the estimated capital expenditures and significant operating costs related to the lifecycle activities required to maintain the current levels of service in order to accommodate projected increases in demand caused by growth, including estimated capital expenditures and significant operating costs related to new construction or to upgrading of existing municipal infrastructure assets. O. Reg. 588/17, s. 5 (2).

(3) Every asset management plan must indicate how all background information and reports upon which the information required by paragraph 3 of subsection (2) is based will be made available to the public. O. Reg. 588/17, s. 5 (3).

(4) In this section,

"2017 Growth Plan" means the Growth Plan for the Greater Golden Horseshoe, 2017 that was approved under subsection 7 (6) of the *Places to Grow Act, 2005* on May 16, 2017 and came into effect on July 1, 2017; ("Plan de croissance de 2017")

"Greater Golden Horseshoe growth plan area" means the area designated by section 2 of Ontario Regulation 416/05 (Growth Plan Areas) made under the *Places to Grow Act, 2005*. ("zone de croissance planifiée de la région élargie du Golden Horseshoe") O. Reg. 588/17, s. 5 (4).

Grading Criteria

Table 3: O. Reg. 588/17 Guidelines Grading Criteria

Grade	O.Reg. Guidelines & Completeness
A	(80-100%) of the regulation completed
B	(60-79%) of the regulation completed
C	(40-59%) of the regulation completed
D	(20-39%) of the regulation completed
E	(0-19%) of the regulation completed

Chapter 4: Qualitative Document Analysis Results

Case Study #1 - City of Hamilton

The City of Hamilton is a single-tier municipality located on the west side of Lake Ontario. It has a population of about 579 2000 and is close to the Greater Toronto Area. The city provides essential services to residents, visitors, business owners, students, and tourists, all of which rely on sustainable infrastructure such as roads, bridges, facilities, water, stormwater, and wastewater. Effective management of the City's infrastructure throughout its lifespan is crucial for delivering high-quality services (City of Hamilton, 2024)

Asset management encompasses not just the physical assets but also the provided services and the delivery of assets at the agreed-upon service levels. Municipalities can maximize capital and operating funds through effective asset management planning, which involves making informed decisions based on evidence. This includes making appropriate infrastructure investments in suitable locations at the correct times to meet required service levels while adhering to Ontario Regulation 588/17: Asset Management Planning for Municipal Infrastructure. The City of Hamilton has implemented various measures under the Infrastructure for Jobs & Prosperity Act to efficiently improve service levels for current and future customers through asset management.

The City of Hamilton's Corporate Asset Management (CAM) office, in collaboration with over 50 asset owners and key stakeholders, has completed the initial edition of the 2022 Waterworks Asset Management (AM) Plan. These initial plans are designed to fulfill the requirements of O.Reg. 588/17, which includes establishing the current levels of service and establishing a baseline for the City's core assets (water, wastewater, stormwater, roads, and bridges) to identify areas for continuous improvement in the next iteration of the AM Plans. The Stormwater

Section is the focus of the City's AMP for this research study (City of Hamilton, 2024)

*Table 4: City of Hamilton Detailed Summary of Stormwater Vertical Assets *Weighted Average*

ASSET CATEGORY	NUMBER OF ASSETS	REPLACEMENT VALUE	AVERAGE AGE (% RSL)	AVERAGE EQUIVALENT CONDITION
VERTICAL ASSETS				
Pump Stations	2	$9.52M	8 years (87%)	1-Very Good
Data Confidence	Very High	Medium	Very High	Low
Flood Control Structure	1	$5.0M	No Data	No Data
Data Confidence	Very High	Low	Very Low	Very Low
Flood Control Gate	1	$2.5M	No Data	No Data
Data Confidence	Very High	Low	Very Low	Very Low
SWM Pond (excl wetlands)	119	$178.5M	24 years (76%)	2-Good
Data Confidence	Medium	Low	Medium	Low
	SUBTOTAL	**$195.52M**	**16 years (80%)**	**2-Good***
	Data Confidence	**Low**	**Medium**	**Low**

(City of Hamilton, 2024)

*Table 5: City of Hamilton Detailed Summary of Stormwater Linear Assets *Weighted Avera*

LINEAR ASSETS				
Trunk Stormwater Main (>600mm diameter)	607.79 km	$1.084B	39 years (60%)	2-Good
Data Confidence	High	Medium	Medium	Medium
Local Stormwater Main (<600mm diameter)	655.70 km	$702.07M	39 years (58%)	2-Good
Data Confidence	High	Medium	Medium	Medium
Catchbasin	49,882	$460.18M	No Data	2-Good
Data Confidence	Medium	Low	Very Low	Low
Maintenance Hole	20,307	$203.07M	40 years (60%)	2-Good
Data Confidence	Medium	Low	Medium	Low
Catchbasin Maintenance Hole	1,101	$11.01M	51 years (49%)	3-Fair
Data Confidence	Medium	Low	Medium	Low
Oil and Grit Separator (OGS)	84	$3.36M	15 years (41%)	3-Fair
Data Confidence	High	Low	High	Low
Storm Sewer Lateral	No data	No data	No data	No data
Data Confidence	Very Low	Very Low	Very Low	Very Low
Minor Culvert	3,448	$172.40M	4 years (92%)	3-Fair
Data Confidence	Medium	Low	Low	High
Inlet	515	$25.75M	26 years (67%)	2-Good
Data Confidence	Medium	Low	Medium	Low
Outfall	917	$45.85M	34 years (57%)	3-Fair
Data Confidence	Medium	Low	Medium	Low
Ditches	1,603.04 km	$240.46M	No Data	No Data
Data Confidence	Low	Low	Very Low	Very Low
Low Impact Development (LID)	No Data	No Data	No Data	No Data
Data Confidence	Very Low	Very Low	Very Low	Very Low
Swales	No Data	No Data	No Data	No Data
Data Confidence	Very Low	Very Low	Very Low	Very Low
	SUBTOTAL	**$2.949B**	**28 years (81%)**	**2-Good***
	Data Confidence	**Medium**	**Medium**	**Low**
	TOTAL	**$3.144B**	**22 years (73%)**	**2-Good***
	Data Confidence	**Medium**	**Medium**	**Low**

(City of Hamilton, 2024)

Considering the data confidence for the summary of stormwater assets for the City of Hamilton, there may be some gaps due to assay inventory cataloging of storm asset inventory; therefore, the lack of a completed asset registry for stormwater was

flagged as a continuous improvement target for the city.

City of Hamilton Stormwater Assets Condition Assessment

The condition refers to the physical state of the wastewater assets. It assesses the physical integrity of these assets or components and is the preferred measurement for planning lifecycle activities to ensure assets reach their expected useful life. The continuous improvement item listed the stormwater asset condition for review of existing internal condition assessments.

Table 6 : City of Hamilton Stormwater Assets Condition Methodology

EQUIVALENT CONDITION GRADING	CONDITION DESCRIPTION	% REMAINING SERVICE LIFE	STORM MAIN	MINOR CULVERTS CONDITION	CATCHBASIN
1-Very Good	The asset is new, recently rehabilitated, or very well maintained. Preventative maintenance required only.	>79.5%	PACP Score = 1; If PACP unknown, WRC Structural Score =1; If both unknown: RSL	Maximum Condition Score = 0 during inspection	N/A
2-Good	The asset is adequate and has slight defects and shows signs of some deterioration that has no significant impact on asset's usage. Minor/preventative maintenance may be required.	59.5% – 79.4%	PACP Score = 2; If PACP unknown, WRC Structural Score =2 or Lined Pipe; If all unknown: RSL	Maximum Condition Score =1 during inspection	Good
3-Fair	The asset is sound but has minor defects. Deterioration has some impact on asset's usage. Minor to significant maintenance is required.	39.5% - 59.4%	PACP Score = 3; If PACP unknown, WRC Structural Score =3; If all unknown: RSL	Maximum Condition Score = 2 during inspection	Fair
4-Poor	Asset has significant defects and deterioration. Deterioration has an impact on asset's usage. Rehabilitation or major maintenance required in the next year.	19.5% -39.4%	PACP Score = 4; If PACP unknown, WRC Structural Score =4; If all unknown: RSL	Maximum Condition Score = 3 or culvert was identified as maybe needing a replacement during inspection.	Poor
5-Very Poor	Asset has serious defects and deterioration. Asset is not fit for use. Urgent rehabilitation or closure required.	<19.4%	PACP Score = 5; If PACP unknown, WRC Structural Score =5; If all unknown: RSL	Maximum Condition = 4 or culvert was identified as needing replacement in inspection.	N/A

Table 7: Stormwater Vertical Asset Condition Distribution

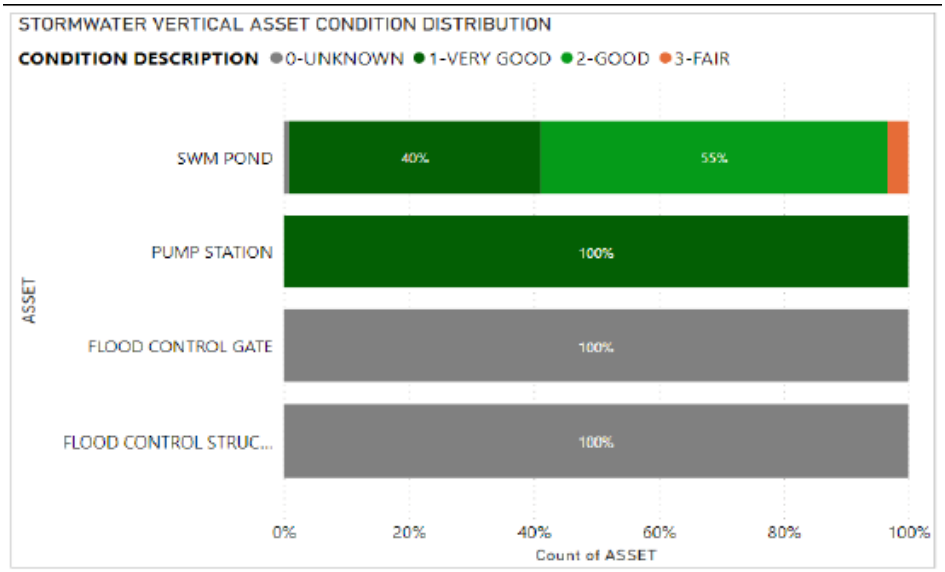


Table 8: Stormwater Linear Asset Condition Distribution

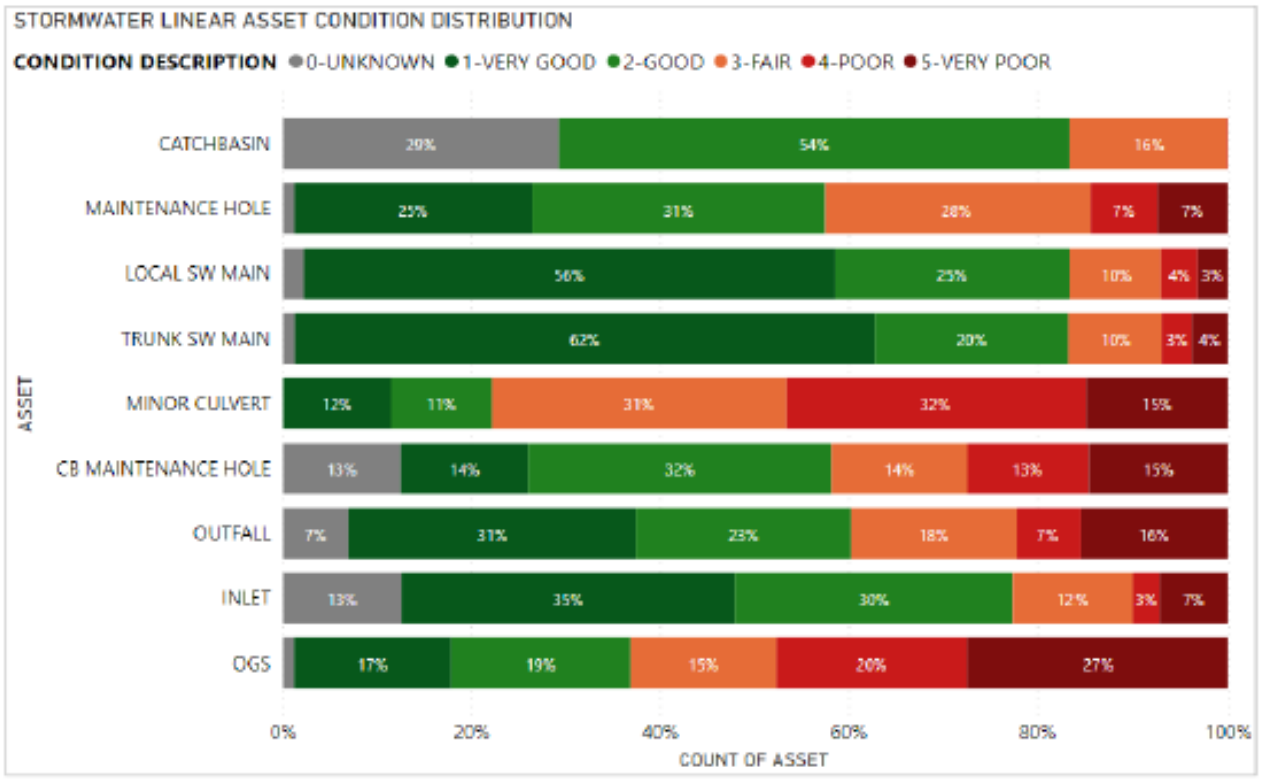


Table 9: City of Hamilton Stormwater Asset Risks and Existing Controls

SERVICE OR ASSET AT RISK	WHAT CAN HAPPEN	RISK RATING	EXISTING CONTROLS
Stormwater network	Lack of comprehensive stormwater model so City cannot predict where flooding may occur	Very High	Modelling is currently being completed.
Orphan Stormwater Asset	Asset fails due to no maintenance or inspection program	High	None
SWM Pond	Pipe Blockage	High	Control Structure Inspections; Compliance Inspections; Rainfall Inspections
SWM Pond	Invasive species reduce storage capacity (e.g. phragmites, goldfish)	High	Contract works; Educate public on not discarding pets
Low Impact Development	Lack of lot level controls on LIDs necessary to support intensification leads to assets not effectively managing stormwater	High	None
Critical Stormwater Main	Blockage due to structural failure or debris	High	CCTV inspection program
Pump Station	Pump failure or station reaches capacity.	High	Monthly station checks and verifications by operators

The city also identified critical assets and their failure mode using the Risk controls to ensure proactive maintenance and operations activities.

Table 10: City of Hamilton - Stormwater Critical Assets

CRITICAL ASSET(S)	FAILURE MODE	IMPACT
Storm Water Management Pond	Physical Failure	Contaminants don't settle out and pollutes watercourse and/or pipes reach capacity causing flooding.
Critical Stormwater Main	Physical Failure	Storm backup might occur at catchbasins or laterals and flood streets/properties.
SCADA	Essential service interruption	System failure causing service interruption to pump station

Table 11 : City of Hamilton - Customer Levels of Service

TYPE OF MEASURE	LEVEL OF SERVICE	SOURCE	PERFORMANCE MEASURE	CURRENT PERFORMANCE	TREND BASED ON PLANNED BUDGET
Condition	Provide reliable stormwater services with minimum flooding.	Annual Customer Engagement Survey	76.4% of survey respondents have not experienced flooding impacts on their property	Fairly Satisfied	Maintain Trend
			48.4% of survey respondents are concerned with flooding on their property	Unsatisfied	Trending downwards
			76.4% of survey respondents have not experienced flooding impacts on their property	Fairly Satisfied	Maintain Trend
			92.9% of survey respondents did not have to delay or cancel plans due to roads flooding	Very Satisfied	Maintain Trend
		Confidence levels		Medium	
		Age-based	Average condition of pump stations	Very Good	Trending downwards
		Age-based	Average condition of stormwater ponds	Good	Maintain Trend
		Confidence levels		Low	
		Age & Condition Based	Average condition of stormwater main	Good	Maintain Trend
		Confidence levels		Medium	
		Unknown	Average condition of flood control gate/structure	Unknown	Trending downwards
		Confidence levels		Very Low	
Function	Ensure stormwater is being collected responsibly.	Annual Customer Engagement Survey	40.1% of survey respondents do not think that Hamilton behaves responsibly when returning stormwater back to the environment	Unsatisfied	Maintain Trend
		Confidence levels		Medium	
Capacity	Ensure stormwater assets are used and within design capacity.	Annual Customer Engagement Survey	30.3% of survey respondents were connected to the storm sewer	Low	Maintain Trend
		Confidence levels		Medium	

Table 12: City of Hamilton -Technical Levels of Service

LIFECYCLE ACTIVITY	PURPOSE OF ACTIVITY	ACTIVITY MEASURE	CURRENT PERFORMANCE*	TARGET	RECOMMENDED PERFORMANCE **
Acquisition	Ensure stormwater assets are used and within design capacity.	% of stormwater ponds inspected before assumption	100%	100%	100%
Operation	Provide reliable stormwater services with minimum flooding.	METRIC -# of Oil & Grit Interceptor Inspections	862	No Data	No Data
		Mainline sewers inspected per year	78 km	100	100
		% of stormwater pond inspections completed	100%	100	100%
		% Watercourse erosion inspection per year	No Data	33%	33%
		# inlet/outlet inspections completed	2,267	No Data	No Data
Maintenance	Provide reliable stormwater services with minimum flooding.	% of stormwater ponds cleaned out versus ponds requiring clean out	No Data	No Data	No Data
Renewal	Provide reliable stormwater services with minimum flooding.	Sewermain CIPP rehabilitation km/yr (4113)	4.5 km	No Data	No Data

Note: * Current activities related to Planned Budget.
**** Expected performance related to forecast lifecycle costs.**

Table 13: City of Hamilton - major operating and maintenance lifecycle activities for vertical Stormwater assets

ASSET	LIFECYCLE STAGE	LIFECYCLE ACTIVITY	FREQUENCY	2021 COST	UNIT
Pump Station	Operation	Inspection	Monthly	$639.54	annually
		Calibration	Ad Hoc	$73.34	annually
	Maintenance	Preventative Maintenance	Seasonal/ Annual	$195.03	annually
		Reactive Maintenance	Ad Hoc	$2,095.07	annually
Wet SWM Ponds	Operation	Sediment Depth Surveys	5-year cycle	$100,000.00	annually
		Water Level Monitoring	5 year cycle	$75,000.00	annually
	Maintenance	Full Dredging	25-year cycle	$1,650,000.00	annually
All SWM Ponds	Operation	Forebay Dredging	10-year cycle		
		Grass Cutting	6x per year	$110,000.00	annually
		Litter Collection	2x per year		
		Compliance Inspections	annually	$236.00	per unit
		Rainfall Inspections	ad hoc	$118.00	per unit
		Control Device Inspections	annually	$118.00	per unit
		Water Quality Sampling	6x per year	$60,000.00	annually
		Invasive Species Management	ad hoc	$450,000.00	annually
	Maintenance	Minor Repairs	ad hoc	$5,000.00	annually
		Sign Replacement	ad hoc	$10,000.00	annually
		Fencing Replacement	ad hoc	$50,000.00	annually
		Entry Treatment Replacement	ad hoc	$100,000.00	annually
		Administrative Tasks	annually	$675,000.00	annually
Flood Control Structure / Gate	Maintenance	Minor Repairs	ad hoc	$20,000	annually
	Operation	Rainfall Inspections	ad hoc	$118.00	per occurrence

Table 14: City of Hamilton - major operating and maintenance lifecycle activities for Linear Stormwater assets

ASSET	LIFECYCLE STAGE	LIFECYCLE ACTIVITY	FREQUENCY	2021 COST	UNIT
Minor Culvert	Operation	Inspection	5 year cycle	$15,000.00	per year
		Cleaning	Ad Hoc	$1,000.00	Per instance
	Maintenance	Ditching	Ad Hoc	$500.00	Per instance
		Repair	Ad Hoc	No data	
Swales	Maintenance	Minor Maintenance	Ad Hoc	No data	
Catchbasins	Operation	Inspection	Ad Hoc	$61.00	Per instance
		Cleaning	Ad Hoc	$250.00	Per instance
OGS	Operation	Inspection Program	Monthly	$30.00	Per instance
		Cleaning	Ad Hoc	$450.00	Per instance
Inlet/Outfalls	Operation	Inspection	Annually	$30.00	Per instance
		Cleaning	Ad Hoc	$450.00	Per instance
	Maintenance	Minor Repairs	Ad Hoc	$2,000.00	Per instance

Table 15: City of Hamilton - Stormwater Linear Assets Age Profile

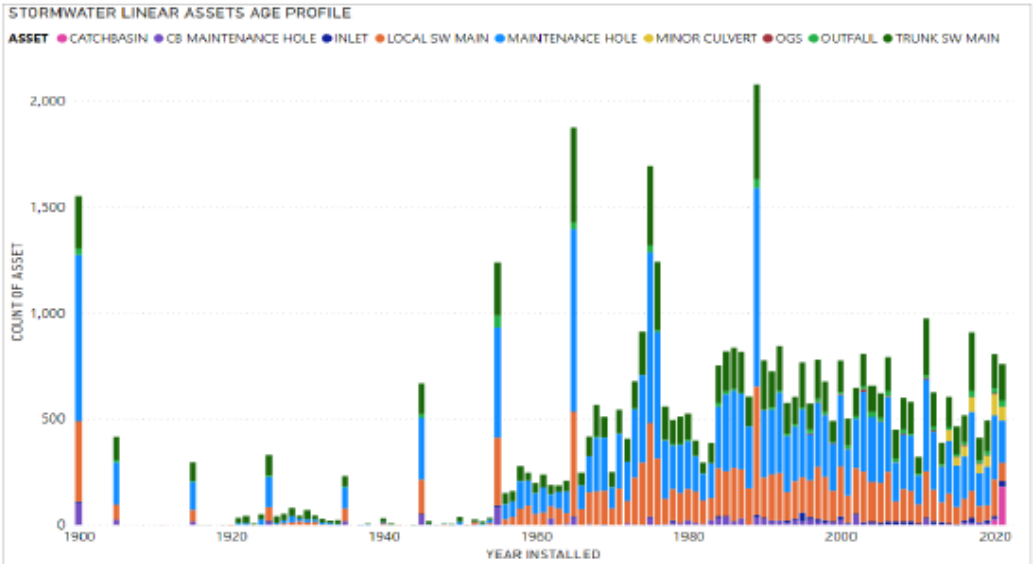
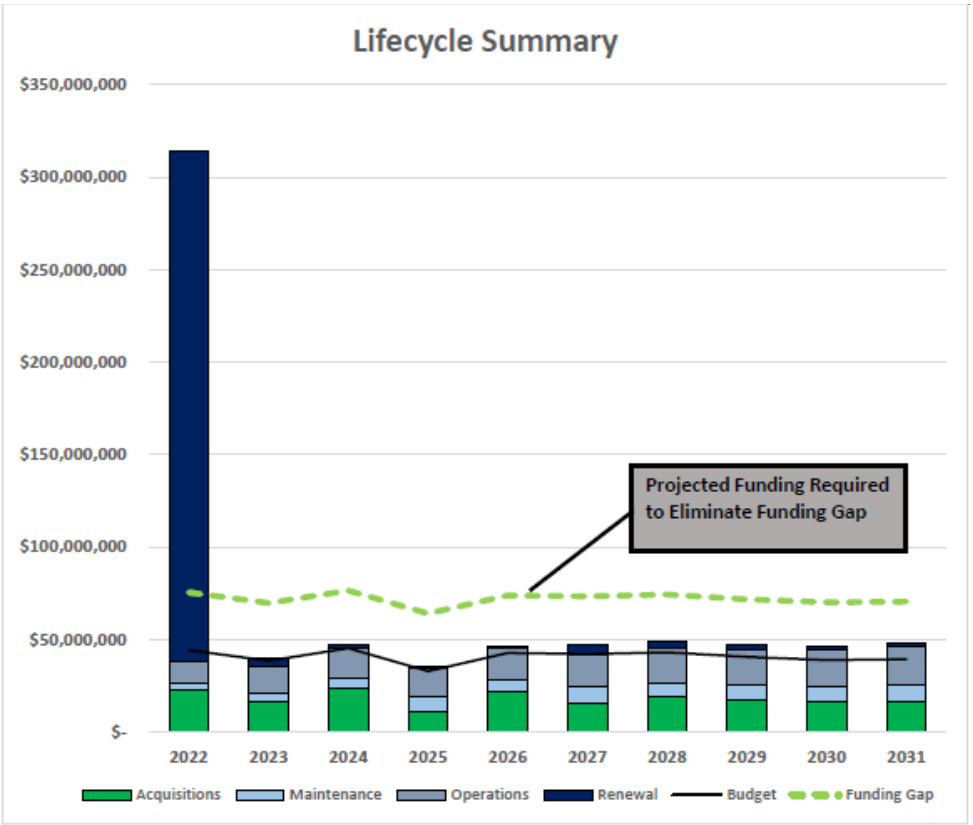


Table 16: City of Hamilton - Stormwater Assets Lifecycle Financial Summary



The plan requires additional funding to handle the anticipated extensive backlog of renewal work. Although there is enough budget to cover most of the ongoing operational and maintenance activities for the planning period, the increasing assumption of asset costs over time could potentially impact the service. An additional

budget will be necessary to cover all planned lifecycle activities, possibly through flexible funds or alternative lifecycle management choices.

City of Hamilton Results / Findings

The stormwater sections of Hamilton's Waterworks asset management plan effectively meet the requirements outlined in O.Reg.588/17. By including most asset management requirements from the regulation, except for the proposed levels of service that were not mandatory by the July 1, 2022, deadline, the City is demonstrating its commitment to compliance. Additionally, there is a need for the city to consider integrating climate change impact and demand analysis to accommodate the city's growth, recognizing the importance of improving data quality to align with asset management best practices. The city's use of stormwater infrastructure management to manage relevant policies and regulations and identify interconnections demonstrates thorough planning and execution.

The City's comprehensive approach is evident in the AMP, which includes detailed information on storm assets, asset hierarchy, asset renewal ranking, and asset usage and performance in the asset inventory. This demonstrates a deep understanding that goes beyond the required regulations. It is worth noting that the AMP adheres to asset management regulation with no notable exclusions. The ongoing focus on improving data confidence, asset valuation, and forecasting will further enhance the AMP. Integrating all O.Reg.588/17 requirements and asset management best practices into the City's financial strategy and state of local infrastructure sections is crucial for ensuring the long-term sustainability of its stormwater infrastructure. The focus on long-term sustainability plays a crucial role in environmental protection and climate change mitigation, as it enhances the resilience of infrastructure systems and lowers the risk of asset failure, thereby reducing potential ecological impacts from such events.

Case Study #2 – City of Brantford

The City of Brantford, situated in Ontario, Canada, is a significant urban hub in Canada's economic core. Situated close to the Grand River and essential consumer and industrial markets across North America, Brantford has a rich history shaped by its strategic location. Through progressive revitalization efforts, the city has cultivated a mix of historical and modern elements, creating a vibrant environment for residents, visitors, and businesses. With a focus on promoting economic diversity and offering quality employment opportunities, Brantford also prioritizes initiatives to improve its residents' overall quality of life (City of Brantford, 2021). Situated in Southwestern Ontario along the Grand River, Brantford has a population of 104,688 as of 2021. Despite being surrounded by Brant County, the city has its separate municipal government. The City of Brantford utilizes asset management to effectively oversee its infrastructure assets and make informed investment decisions, recognizing its vital role. By leveraging asset management, the city aims to ensure reliable and affordable services for its residents while mitigating risks (City of Brantford, 2021). Additionally, the city emphasizes accurate data and forecasting future growth to align infrastructure management with evolving service demands, thus ensuring the sustained fulfillment of present and future service needs (City of Brantford, 2021).

In the City of Brantford, stormwater assets encompass a variety of components involved in managing stormwater, including collection, transmission, treatment, retention, infiltration, control, and disposal. These assets are categorized under environmental services and are supervised by the infrastructure planning team within public works. The City of Brantford is accountable for owning and upkeeping numerous assets in the stormwater asset category, which is the focus of the current research study.

Table 17: City of Brantford, Stormwater Assets' Inventory, Replacement Cost, and Condition Origin and Confidence Levels

	Inventory			Replacement Cost			Condition		
Asset Type	**Inventory (incl. Quantity and Age) From**	**Data Confidence Level**	**Data Confidence Description**	**Replacement Cost From**	**Data Confidence Level**	**Data Confidence Description**	**Condition From**	**Data Confidence Level**	**Data Confidence Description**
Gravity Main	GIS layer, swGravityMain	Medium	GIS inventory complete with some assumptions.	2019 Master Servicing Plan Appendix B, Assumed similar to Wastewater	Low	Estimated based on internal Class D pricing, but assumed similar to wastewater cost.	CCTV Inspection Structural Score, Size, Material Service Life	Medium	Formal condition assessment, but annual program not yet encompassing all assets.
Maintenance Holes	GIS layer, swManhole	Medium	GIS inventory complete with some assumptions.	Asset Management 2020 Unit Costs	Medium	Estimated based on internal Class D pricing.	Manhole Condition Assessment program, Service Life	Medium	Formal condition assessment, but annual program has only encompassed 10% of assets.
Flood Gates	GIS layer, swSluiceGate	High	GIS inventory and condition assessment complete.	2020 Flood Gates Condition Assessment completed by AECOM	Medium	Estimate by Consultant, but draft form and some costs were extrapolated.	2021 Flood Gates Condition Assessment completed by AECOM	High	Formal condition assessment complete.
Stormwater Pump Station & Chamber	GIS layer, swNetworkStructure	Medium	GIS inventory complete, but no inventory of facility components (e.g. pumps).	2019 Master Servicing Plan Appendix B, Assumed similar to Wastewater	Low	Estimated based on internal Class D pricing, but assumed similar to wastewater cost.	Service Life	Low	Service life can be a predictor of condition, but does not always indicate the true condition.
Inlets	GIS layer, swInlet	Low	GIS inventory not complete.	Asset Management 2020 Unit Costs	Low	Estimated based on internal Class D pricing.	Service Life	Low	Service life can be a predictor of condition, but does not always indicate the true condition.
Stormwater Pond	GIS layer, swDetention	Medium	GIS inventory complete with some assumptions.	Based on industry standard unit cots	Low	Estimated based on approximate volume.	Condition Assessment Completed by Amec Foster Wheeler, Internal Inspection Program, Service Life	Medium	Formal condition assessment and inspection program, but not yet encompassing all assets.
Stormwater Services	GIS layer,swLateral Line	Low	GIS inventory not complete.	Asset Management 2020 Unit Costs	Low	Estimated based on internal Class D pricing.	Material Service Life	Low	Incomplete data set. Service life can be a predictor of condition, but does not always indicate the true condition.
Oil and Grit Separators	GIS layer, swManhole	High	GIS inventory complete with some assumptions.	Environmental Services Unit Cost	Low	Estimated based on high level estimate.	Service Life, 2020 Inspection Reports	Medium	Based on service life. Preventative maintenance inspections occur on all assets to ensure they're cleaned and in working order.
Outfalls	GIS layer, swDischargePoint	Low	GIS inventory not complete	2019 Master Servicing Plan Appendix B, and Industry standard unit costs	Low	Estimated based on internal Class D pricing, but assumed similar to wastewater cost	2017 Open Drains Condition Assessment completed by GM Blue Plan	Low	Formal condition assessment, but data set is incomplete with many unknowns.
Ditches	GIS layer, swOpenDrain	Low	GIS inventory not complete	Environmental Services Unit Cost	Low	Estimated based on high level estimate.	2017 Open Drains Condition Assessment completed by GM Blue Plan	Low	Formal condition assessment, but data set is incomplete with many unknowns.

(City of Brantford, 2021)

Table 18: City of Brantford - Summary of Stormwater Assets

Asset	Quantity	Unit	Replacement Cost	Average Age (years)	Average Estimated Service Life	Percentage of Estimated Service Life	Average Condition Score	Average Condition Description
Stomwater Assets Total			**$480.7M**	**28**	**71**	**40%**	**1.5***	**FAIR**
Storm Pump Station	1	count	$2.21M	28	75	37%	2.0	FAIR
Storm Chambers	1	count	$13.5K				1.0	GOOD
Stormwater Ponds	23	count	$16.1M	22	55	40%	2.0	FAIR
Gravity Mains	413.6	km	$361.7M	43	97	44%	1.0	GOOD

Inlets	12,290	count	$30.8M	39	100	39%	1.4	GOOD
Maintenance Holes	6,222	count	$28.0M	40	100	40%	1.5	FAIR
Storm Services	5,010	count	$13.1M	15	72	21%	1.2	GOOD
Oil and Grit Separators	25	count	$1.9M	14	20	70%	1.6	FAIR
Flood Gates	39	count	$1,878,717	37	28	132%	1.9	FAIR
Outfalls	290	count	$556,696	53	90	59%	1.1	GOOD
Ditches	121.3	km	$24,300,000	-	-	-	1.1	GOOD
Municipal Drain	318	m	$63,600	-	-	-	-	-

*Denotes Weighted Average

Figure 4: City of Brantford- Stormwater Assets Lifecycle Stages

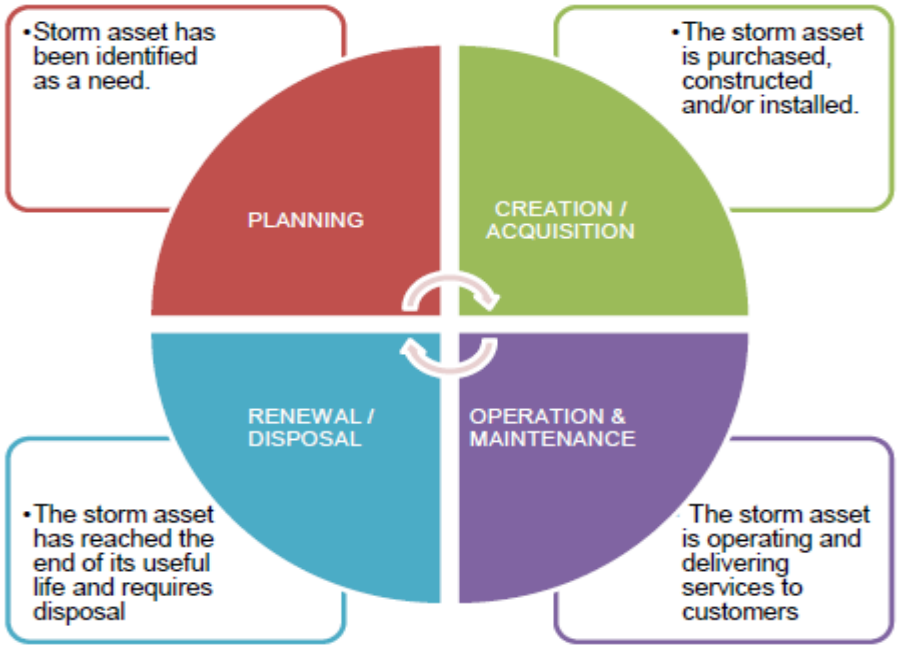


Figure 5 : City of Brantford - 10-Year Lifecycle Cost Per Stormwater Asset Type

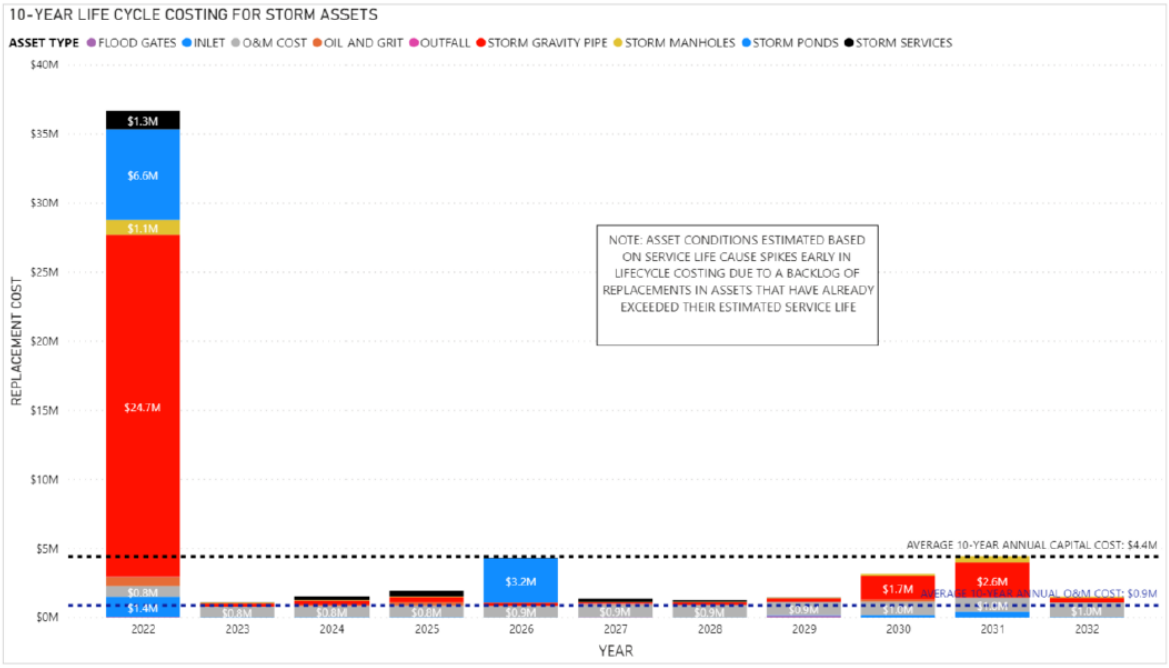


Figure 39: 10-Year Lifecycle Cost Per Stormwater Asset Type

Notes:

1. O&M Costs are from the numbers reported in the 2021 Preliminary Operating Budget and assumed to be projected 3% per year to account for inflation. These O&M Costs are associated with both Treatment and Distribution and are partially broken down in **Table 28.**
2. Assets with formal condition assessments which contained forecasting (i.e. flood gates) were included based on the estimated replacement/repair year, and referred to in **Table 24.**
3. Gravity main replacement was based on service life unless it was estimated to have a poor WRC structural score or be undersized, in which case it was estimated to be in 2022 to clear the backlog.
4. If a condition assessment was completed without a forecast (e.g. maintenance holes, stormwater ponds), if condition was poor, works occurred in 2022, if condition was fair, works occurred in 2026.
5. For all other assets where no formal forecast was available, the replacement year is based on the estimated remaining service life of each asset

Figure 6: Existing Capital Budget Forecast from 2021 - 2030 for Stormwater Assets

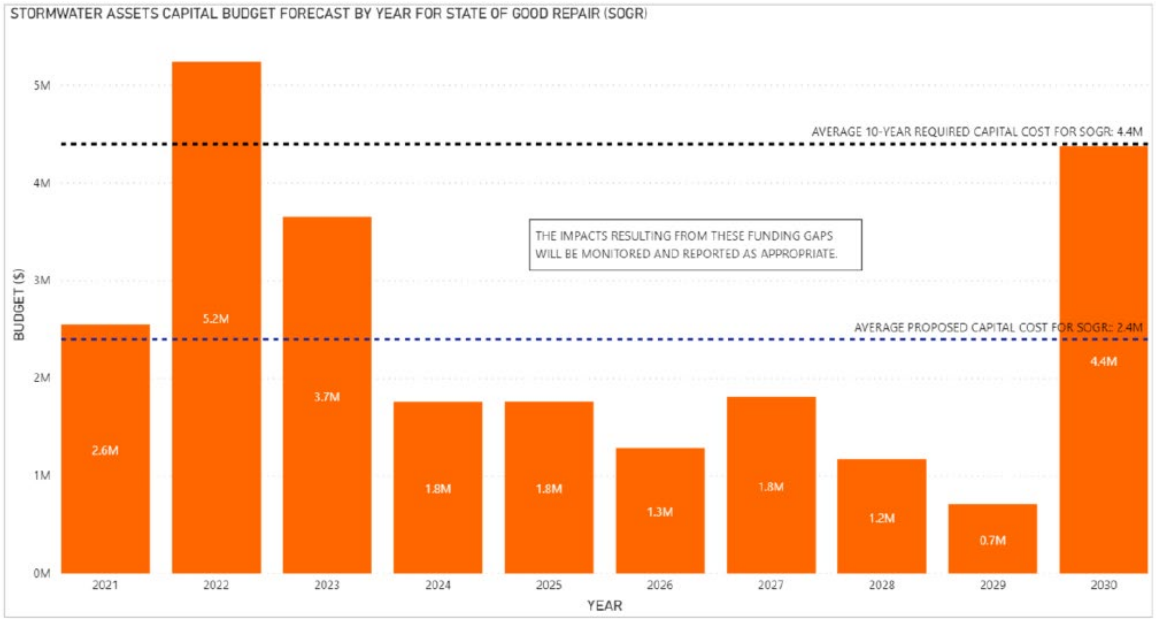


Table 19: City of Brantford -O. Reg 588/17 Stormwater Technical Levels of Service

Service	Service attribute	Technical levels of service (technical metrics)	2019	2020
Stormwater	Scope	1. Percentage of properties in municipality resilient to a 100-year storm.	N/A	55.4%
		2. Percentage of the municipal stormwater management system resilient to a 5-year storm.	N/A	52.3%

Table 20: City of Brantford - Newly Defined Level of Service KPI

Customer Level of Service	Technical Level of Service	2019 KPI	2020 KPI	Units
Quality	% of stormwater system resilient to 2-year storm	N/A	47.7%	%
	Number of basement flooding prevention grant funding applications	N/A	3	Count
	Number of storm events	12	10	Count
	Largest return year storm event	1.9	1.8	Return year
	Number of overland flood complaints	N/A	0	Count
	Length of newly installed stormwater gravity main	6.91	0.796	km
	Number of abandoned stormwater gravity main segments	19	16	Count
	No of basement flooding complaints	N/A	1	Count
	Number of Right of Way Flooding complaints	N/A	2	Count
	Number of stormwater pond complaints	N/A	2	Count
Cost Effectiveness	Number of hours spent preparing for storm weather events	N/A	N/A	Hours
	Cost spent preparing for storm weather events	N/A	N/A	$
Environmental Sustainability	Number of waterwise gardening participants	N/A	320	Count
	Number of rain barrels sold	N/A	200	Count
Responsiveness	Length of time to respond to flooding service request	N/A	N/A	Hours

Table 21: City of Brantford -Current Energy Performance of Stormwater Facilities

Facility	Address	Electricity (kWh)*	Natural Gas (m3)*	GHG Emissions (kg)*	Annual Flow (Mega Litres)	Energy Intensity (ekWh/Mega Litre)*
Stormwater P.S.	59 Icomm Dr	311,019	N/A	9,478	2269	137.1

*Based on information provided in the 2019 Corporate Energy Management Report

Table 22: City of Brantford - Stormwater & Wastewater Assets' Estimated Service Life

Asset	Estimated Service Life
Gravity Main	ABS (Acrylonitrile Butadiene Styrene) – 90 years, Concrete – 100 years, Clay – 70 years, Cast Iron – 90 years, PVC (Polyvinyl chloride) – 90 years, Asbestos Cement – 70 years, Fibreglass Reinforced Pipe – 90 years, Ductile Iron – 65 years, HDPE (High Density Poly Ethylene) 90 years, Unknown – 50 years, Steel – 90 years, Polyethylene – 90 years
Maintenance Holes, Inlets, Chambers	100 years
Stormwater Pump Station	49 years
Stormwater Pond	55 years
Stormwater Services	ABS – 90 years, Concrete – 100 years, Clay – 70 years, Cast Iron – 90 years, PVC – 90 years, Asbestos Cement – 70 years, Fibreglass Reinforced Pipe – 90 years, Ductile Iron – 65 years, HDPE 90 years, Unknown – 50 years
Oil and Grit Separator	20 years

City of Brantford Results / Finding

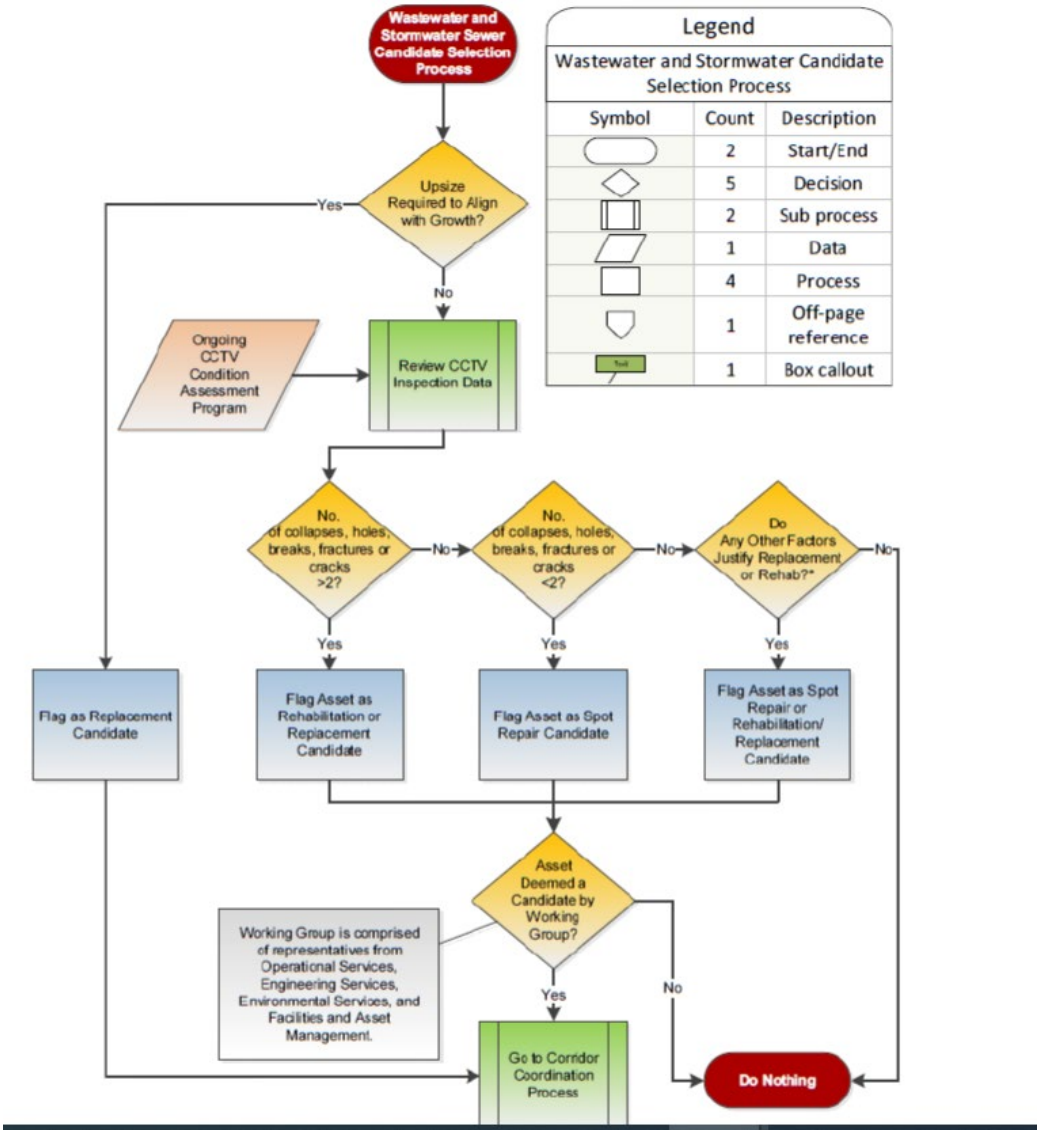
The City of Brantford is responsible for managing and maintaining various stormwater assets, which are generally considered to be in fair condition and have an estimated replacement cost of around $481 million. The confidence in these assets' inventory and condition data is assessed at a medium level due to incomplete ArcGIS inventory information. Despite this, assets that can undergo visual inspection show higher inventory and condition data levels. However, several assessment programs still have not covered all assets. There is also a need for increased confidence in asset

inventory and condition data, which has been recognized as an area for improvement in the next iteration of the Asset Management Plan (AMP).

The City of Brantford has exceeded the requirements specified in O. Reg by merging stormwater asset information with energy performance. Specifically, the annual energy data associated with City facilities in the Corporate Energy Management Plan (CEMP) has been utilized to assess energy performance. The city is committed to continuously improving the energy efficiency of all facilities through the Climate Change Action Plan and Climate Lens. As part of these initiatives, the city is getting ready to set targets for improving the energy efficiency of facilities and reducing the carbon footprint associated with stormwater. Despite this progress, there is still a gap in connecting stormwater asset planning efforts with climate change and green infrastructure planning, a common issue among many other municipalities.

The stormwater sections of the Brantford environmental service asset management plan effectively meet the requirements outlined in O.Reg.588/17. By including most asset management requirements from the regulation, except for the proposed levels of service that were not mandatory by the July 1, 2022, deadline, the City is demonstrating its commitment to compliance. Additionally, the city needs to consider integrating climate change impact. Brantford did an excellent job with demand analysis to accommodate the city's growth, recognizing the importance of improving data quality to align with asset management best practices.

Figure 7: City of Brantford -Stormwater Linear Asset Business Process



The city's use of stormwater infrastructure management to manage relevant policies and regulations and identify interconnections demonstrates thorough planning and execution. The City's comprehensive approach to lifecycle stormwater assets business processes and critical lifecycle stages of stormwater assets, lifecycle activities, risks of lifecycle activities, and 10-year lifecycle costs of stormwater assets. Integrating all O.Reg.588/17 requirements and asset management best practices into the stormwater asset section summary shows that stormwater assets have an overall replacement cost of around $4801 million. These assets are, on average, 28 years old, which is 40% of their estimated service life. The average condition scores are

rounded to one decimal place, showing how close the scores are to another rating. These scores were used to calculate the asset group's weighted average condition score. Afterward, the scores are rounded to the nearest whole number in the subsequent sections. Additionally, stormwater assets are in Fair condition, but they are close to the threshold between Fair and Good condition, with a weighted average score of 1.5.

Case Study #3 – City of Ottawa

Ottawa, the capital of Canada, is in the eastern part of southern Ontario, near Montréal and the U.S. border, along the Ottawa River, with Parliament Hill as its main attraction. Known for its impressive Victorian architecture, the city houses prestigious museums like the National Gallery of Canada, which is famous for its Indigenous and Canadian art collections. The City of Ottawa's municipal government provides public services and enforces local by-laws. In 2021, the city's population was 1,017,449, and the metropolitan area was home to 1,488,307 people, making Ottawa Canada's fourth-largest city and metro area. (City of Ottawa, 2022)

The city has implemented a thorough Asset Management program that utilizes a unified business approach covering planning, finance, engineering, maintenance, and operations to oversee existing and new infrastructure efficiently. This all-encompassing infrastructure management strategy is focused on maximizing benefits, reducing risks, and providing dependable community services while being mindful of social, cultural, environmental, and economic factors. (City of Ottawa, 2016)

The city’s program for Comprehensive Asset Management oversees all aspects of asset management throughout its lifecycle by integrating with the Corporate Planning Framework to align with the city's strategic objectives, essential business systems, legislation, and regulations. It also establishes a framework that offers a clear line of sight between the Asset Management program and corporate objectives and strategies. Additionally, the program is dedicated to delivering approved service levels to current and future customers and communities effectively and efficiently through the planning, design, construction, acquisition, operation and maintenance, renewal, and disposal of assets. (City of Ottawa, 2022)

The City of Ottawa has successfully implemented a thorough Asset Management program that exceeds the expectations specified in O.Reg. 588/17. The municipality has gained a deep comprehension of its infrastructure assets. It has consistently prioritized maintenance, tactfully managing affordability, risk, and service levels in its initial stormwater asset management plan formulated in 2022.

Figure 8: City of Ottawa - Stormwater Asset Categories and Types

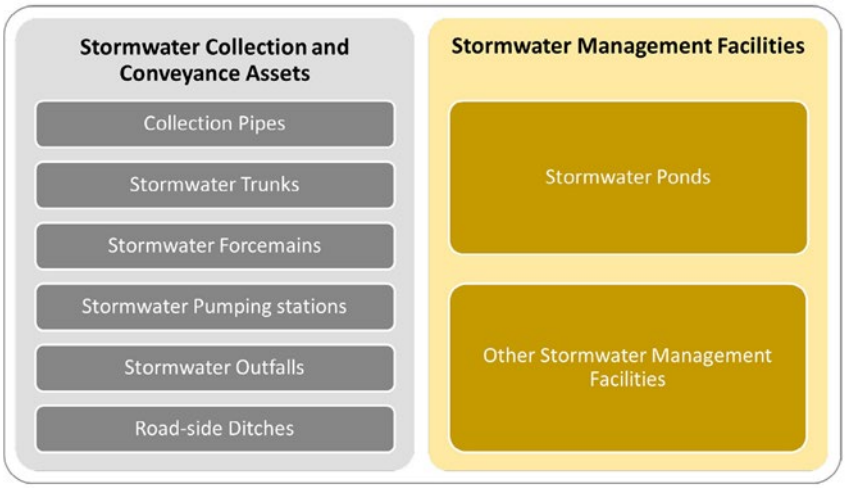


Figure 9: City of Ottawa - State of Local Infrastructure

Inventory and Valuation

The assets covered in the Stormwater AMP have a replacement value of approximately $12.7 billion. This includes an inventory of approximately 3,000 kilometres of pipes, 14 pump stations, nearly 1,700 outfalls, up to 6,000 kilometres of roadside ditches, 167 ponds, and 95 other facilities.

	Stormwater Collection and Conveyance Assets	Stormwater Management Facilities
Inventory	• 2,919 kilometres of Collection Pipes • 88 kilometres of Stormwater Trunks (2,100 mm diameter or greater) • 3 kilometres of Stormwater Forcemains • 14 Stormwater Pump Stations • 1,686 Stormwater Outfalls • 3,500 – 6,000 kilometres of roadside ditches (estimate)	• 167 Stormwater Ponds • 95 Other Stormwater Management Facilities such as underground storage, oil-grit separators, low impact development facilities, diversion structures and open channel flow control structures
Replacement Costs	$12.2 Billion	$460 Million

Figure 10 : City of Ottawa - Stormwater Assets Average Age

Age and Condition

The age of an asset gives a sense of how close it is to the end of its service life and what renewal interventions may be appropriate. The average age of the City's stormwater assets is shown in the figure below.

Average Age – Stormwater Assets

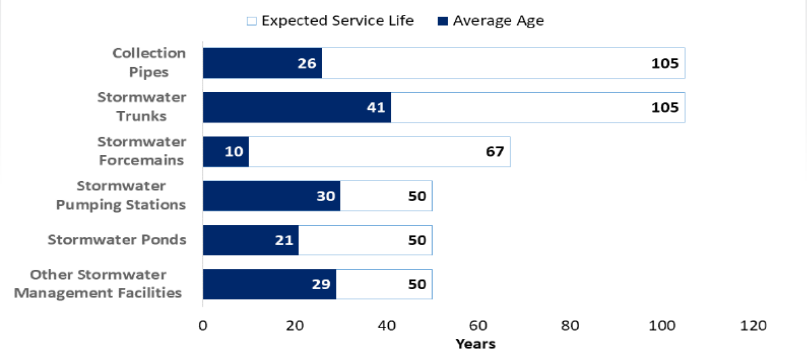


Table 23: City of Hamilton - Stormwater assets condition techniques and frequency

Asset Category	Condition data collection techniques	Frequency
Storm sewers (<2100mm diameter)	Closed Circuit TV inspection	1-to-20-year cycle, dependent on level of risk; some sewers have annual inspection requirements
Storm trunks (>2100mm diameter)	Walkthrough inspection on storm trunks deemed to be nearing end of life; preceded by Closed Circuit TV if less than 3000mm diameter	As required in advance of expected lifecycle replacement
Storm pumping stations	Visual inspection and condition assessment of electrical, mechanical and structural components	Going forward, intention is to complete a 5-year basis
Forcemains	Closed Circuit TV inspection; possible transient and hydraulic analysis; opportunistic pipe and soil sampling; external corrosion detection	Variable
Outfalls	Visual inspection and condition assessment	Variable
Roadside ditches	Inspection is carried out when reactive ditch cleaning work is requested	Variable
Stormwater ponds	Environmental Compliance Approval compliant major and minor inspections; ongoing infiltration monitoring	Once per year
Oil and grit separators	Visual inspection and sediment depth measurement	Once per year
Low impact development	Environmental Compliance Approval compliant inspection (plus informal inspections and monitoring for new pilot projects)	Once per year (or monthly for pilot projects)
Flow control structures	Visual inspection	Once per year

Table 24 : the City of Ottawa, Stormwater asset condition rated scale.

Rating	Rating Description	Percent Life Consumed	Asset Category / Type Metric (Condition Indices)			
			Collection Pipes and Trunks (Percent of Expected Life)	Stormwater Collection and Conveyance Assets		Stormwater Management Facilities (Condition Grade)
				Forcemains (Percent of Life Consumed)	Stormwater Pump Stations (Percent of Expected Life)	
Very Good	**Very Good – Fit for Future** Well maintained, good condition, new or recently rehabilitated	0% to 19%	80% to 100%	0% to 19%	80% to 100%	5
Good	**Good – Adequate for Now** Acceptable, generally in early to mid-stage of expected service life	20% to 39%	60% to 79%	20% to 39%	60% to 80%	4
Fair	**Fair – Requires Attention** In mid-life. Signs of deterioration, requires attention, some elements exhibit deficiencies	40% to 59%	40% to 59%	40% to 59%	40% to 60%	3
Poor	**Poor – Increasing potential of affecting service** Approaching end of service life, condition below standard, large portion of system exhibits significant deterioration	60% to 79%	20% to 39%	60% to 79%	20% to 40%	2
Very Poor	**Very Poor – Unfit for Sustained Service** Near or beyond expected service life, widespread signs of advanced deterioration, some assets may be unusable.	80% or more	0% to 19%	80% to 100%	0% to 20%	1

Figure 11: City of Ottawa- Stormwater Collection and Conveyance Assets Condition

Table 25: City of Ottawa, Preliminary Stormwater Level of Service Measures

Service attribute	Community levels of service	Technical levels of service	Detailed measure	Current
Scope	The extent of the protection provided by the municipal stormwater management system[1]*	% of the municipal stormwater management system resilient to a 1:5 year storm (minor system) *	Storm sewers that will not surcharge to the surface in a 1:5 year storm	94.7%
		% of the municipal stormwater management system resilient to a 1:100 year storm (minor system) *	Buildings that will not experience basement flooding in a 1:5 year storm[2]	86.7%
		% of properties in municipality resilient to a 1:100 year storm (major system) *	Buildings that will not experience basement flooding in a 1:100 year storm[2]	43.6%
		% of properties in municipality resilient to 1:100 year riverine flooding event *	Buildings that will not experience overland flooding in a 1:100 year storm	81.6%
			Buildings that will not experience riverine flooding in a 1:100 year storm	99.4%
Quality	Minimize the presence of material detrimental to water quality	Water Quality Index at major river sites		Excellent: 8 Good: 55 Fair: 29 Marginal: 34 Poor: 7

Figure 12: City of Ottawa - Stormwater Asset Management Strategy

Asset Management Strategy

Practices, Procedures and Tools

The City has well-established overall principles, framework and decision-making approaches for asset management and these are presented in the 2017 Strategic Asset Management Plan. They provide a holistic approach to asset management as demonstrated by the capital investment prioritization process that drives the decision-making towards meeting the desired levels of service at the lowest lifecycle cost.

Future Demand and Service Enhancement

Ottawa's population is expected to increase to 1.4 million people by 2046, a significant increase of 40% over the next 25 years. The City's Official Plan provides the vision for the future growth of the City including areas identified for intensification. The Official Plan is supported by an Infrastructure Master Plan that is currently being updated to ensure that stormwater services will be available to support future growth.

	2046 Projection	Growth since 2018
Population	1,409,650	402,150
Private Households	590,600	194,800
Jobs	827,000	189,500

Source: New Official Plan report to Council (ACS2021-PIE-EDP-0036), October 2021

In addition to the growth and enhancement objectives of the City's master plans, asset management planning also needs to consider the Climate Change Master Plan goals for both resiliency to changing climate and reduction of greenhouse gas emissions. Existing assets must be maintained and new assets brought into service, to meet these various growth and service enhancement objectives.

Figure 13: City of Ottawa- Stormwater Assets Expenditure Forecast

Over the next 10 years, the City will continue investing in infrastructure to support operational expenses, respond to renewal needs, serve growth and provide enhancements.

	Expenditure/Budget Forecast (millions)										
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total
Operating Expenditure	$13.1	$13.7	$14.2	$14.7	$15.3	$15.8	$16.3	$16.8	$17.4	$17.9	$155.2
Capital Budget – Renewal	$54.1	$56.1	$34.0	$64.9	$70.6	$48.8	$51.2	$46.6	$55.2	$47.6	$529.1
Capital Budget - Growth, Enhancement & Strategic Initiatives	$1.8	$7.9	$5.8	$9.1	$7.8	$7.5	$7.6	$7.6	$7.7	$7.8	$70.6

Figure 14: City of Ottawa, Stormwater Assets Financing Strategy

Financing Strategy

The City continues to invest responsibly in maintaining infrastructure and has been increasing its capital investments to align with long-range financial plans. The City's existing funding model keeps the City on track to maintain critical infrastructure in a state of good repair. There is no need to change the current funding model until new service levels are defined in the next version of the asset management plans, which are due in 2025.

Expenditure History

The City has made significant investments on all types of infrastructure and has put a priority on investing in critical infrastructure.

	Expenditure/Budget (millions)				
	2016	2017	2018	2019	2020
Operating Expenditures	$12.4	$13.0	$12.1	$14.2	$14.1
Capital Budget - Renewal	$27.2	$49.4	$49.4	$44.4	$41.5
Capital Budget - Growth, Enhancement & Strategic Initiatives	$1.2	$13.5	$7.5	$4.7	$0.7

Expenditure Forecast

Over the next 10 years, the City will continue investing in infrastructure to support operational expenses, respond to renewal needs, serve growth and provide enhancements.

	Expenditure/Budget Forecast (millions)										
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total
Operating Expenditure	$13.1	$13.7	$14.2	$14.7	$15.3	$15.8	$16.3	$16.8	$17.4	$17.9	$155.2
Capital Budget – Renewal	$54.1	$56.1	$34.0	$64.9	$70.6	$48.8	$51.2	$46.6	$55.2	$47.6	$529.1
Capital Budget - Growth, Enhancement & Strategic Initiatives	$1.8	$7.9	$5.8	$9.1	$7.8	$7.5	$7.6	$7.6	$7.7	$7.8	$70.6

The City of Ottawa Results / Finding

Considering the current circumstances and stated objectives in the Stormwater Asset Management Plan (AMP), potential areas for enhancement consist of:

- Improving data and systems
- Reinforcing flood resilience
- Seeking input on the specific level of service
- Strengthening alignment with long-term financial planning
- Renewing infrastructure
- Building resilience to climate change
- Advancing equity and inclusion

The Stormwater AMP is expected to undergo regular reviews and revisions. These enhancements are expected to be progressively incorporated into subsequent plan releases. Ottawa has effectively implemented an extensive asset program beyond the requirements of O.Reg. 588/17. This effective implementation meets the regulatory requirements and instills confidence in the city's management capabilities. Over the past twenty years, the city has developed a deep understanding of its infrastructure and consistently maintained it while considering affordability, risk, and service levels. The overall condition of stormwater assets is in good shape. Nevertheless, efficient urban stormwater management necessitates using a combination of low-level, conveyance, and end-of-pipe controls to regulate runoff volumes and rates, affecting both flood risk potential and water quality. While investing in public infrastructure assets is a crucial tool for managing flood risk, it is essential to recognize that other factors, such as groundwater, lot grading, and internal plumbing of properties, also contribute to flood risk, and these may not be influenced solely through public infrastructure investment.

The stormwater sections of the City of Ottawa stormwater asset management plan effectively meet the requirements outlined in O.Reg.588/17. By including most asset management requirements from the regulation, except for the proposed levels of service that were not mandatory by the July 1, 2022, deadline, the City is demonstrating its unwavering commitment to compliance, improvement, and monitoring plan. This steadfast commitment should reassure you of the city's dedication to effective stormwater management. Additionally, the municipality integrates stormwater planning well into the flooding impact for the city. Ottawa did an excellent job with financial forecasting and population growth assessment, recognizing the importance of improving data and systems improvement with asset management practices, which will also be reflected in future iterations of the AMPs. The prioritization of asset investments in the city is based on a risk-based approach. Specific frameworks and methods are utilized to assess the risk of different types of assets, considering their significance in delivering services and the potential impact on the number of users. Nevertheless, the stormwater asset management plan of the City of Ottawa did not include the risk chart for its stormwater assets.

Chapter 4.1: Case Study Results Comparisons to O.Reg. 588/17 Guidelines

Table 26 : Selected Municipalities AMP *Comparisons to O.Reg. 588/17* Requirements

O. Reg. 588/17 Requirements	City of Brantford	City of Hamilton	City of Ottawa
State of Local Infrastructure	✓	✓	✓
Levels of Service	✓	✓	✓
Risk Management	Partially	✓	Stated (Not Shown)
Asset Strategy	Partially	✓	✓
Condition Assessment	✓	✓	✓
Financial Strategy	✓	✓	✓
Total Scoring Per O.Reg. 588/17_ Requirements for July 1st, 2022	4/6	6/6	5/6
Above and Beyond O. Reg. 588/17 Requirements due July 1st, 2022			
Linkage to other regulatory and policy framework	Partially	✓	Partially
Climate Change Integration	✓	Partially Stated	Partially Stated
Energy Demand	✓	Partially	X
Continuous Improvement & Monitoring Plan Commitment	✓	✓	✓
Growth & Demand Analysis	Partially	✓	✓
Extra Points Per Literature Review and Industry AM standards	3/5	3/5	2/5
Total Scoring			
The grade for O. Reg. 588/17 requirements + Above & Beyond O.Reg. 588/17	A + B	A + B	A + C

Table 27: O.Reg. 588/17 Completeness & Other Considerations Grading Scale

Grade	O.Reg. guidelines are completed, and AMP was developed above and beyond the requirements.
A	(80-100%)
B	(60-79%)
C	(40-59%)
D	(20-39%)
E	(0-19%)

Upon thoroughly reviewing the Asset Management Plans (AMPs) for comparison, it is evident that municipalities have generally met the requirements of O. Reg. 588/17 and have incorporated additional measures based on best practices to ensure comprehensive asset management plans. However, there is still a significant need to interpret regulatory requirements better and understand how municipalities will fulfill them. According to the document analysis, the Cities of Hamilton and Brantford have excelled in certain aspects beyond the City of Brantford. It is crucial to note that this is not a pass-or-fail assessment due to different interpretations of the requirements. Despite their differences in asset management strategies, they demonstrate some commonalities in adhering to the asset management processes outlined by the Government of Ontario - Asset Management Planning guidelines. This disparity may be attributed to the need for a standardized asset management framework at the provincial level. Although the selected municipalities manage the same stormwater assets, they employ different methodologies for risk management assessment, including the consistent use of a grading scale for condition assessment, ranging from very poor to good.

Furthermore, each selected municipality has integrated a 10-year financial plan to accommodate demand and growth forecasts, ensuring that the assets meet service levels. However, due to variations in funding sources, the estimated financial needs for stormwater asset management differ among the municipalities. Asset management is an evolving field, and as indicated by the different strategies employed by the selected municipalities, reliance on best practices is needed to maximize the value derived from asset management programs.

In summary, although municipalities' benchmarks go above and beyond what the regulation requires, they measure their understanding of how they have implemented the AMPs and their alignment with infrastructure asset planning.

Chapter 5: Discussion, Conclusion and Recommendations

In the context of O. Reg. 588/17, it is imperative to examine the extent to which municipalities comply with the stipulated requirements. While recognizing the possibility of variation in compliance levels across cities, it is essential to emphasize the necessity for adherence to these requirements. An evaluation of compliance with O. Reg. is contingent on a grading scheme that considers the diverse levels of success achieved by three selected municipalities, considering the specific regulatory requirements and the varying degrees of difficulty in meeting them.

Notably, the grading scheme accommodates the challenges posed by some aspects of the regulation while also considering the levels of achievement and the associated difficulty level. An important aspect to consider is the intergovernmental relations issue, where the province establishes requirements for municipalities without comprehensive testing and fails to account for the resource limitations smaller municipalities face in meeting higher levels of government demand, thereby introducing elements of practicality and feasibility important on a go-forward basis. Municipalities encounter numerous challenges, and failure to meet the asset management planning (AMP) requirements could potentially result in the forfeiture of intergovernmental grants or provincial funding. The linkage between asset management planning and intergovernmental grants warrants further research, although it falls beyond the scope of the present study.

Importance of the Research

The significance of stormwater asset management research in Ontario municipalities cannot be overstated due to the following critical reasons:

Addressing Infrastructure Challenges:

Efficient stormwater management is pivotal for mitigating flooding risks and upholding water quality. It plays a fundamental role in ensuring the resilience of urban

infrastructure systems. This research endeavours to identify avenues for enhancing infrastructure planning and maintenance strategies by scrutinizing existing practices and compliance with regulatory frameworks such as O.Reg. 588/17 (Ontario Government, 2021)

Sustainable development

Sustainable development principles are crucial for harmonizing economic advancement with environmental stewardship and societal well-being. By leveraging improved asset management methods, municipalities can optimize resource allocation, alleviate ecological impacts, and promote long-term sustainability in urban water management.

Influencing Decision-Making and Policy:

The outcomes of this study can shape policies at local and state levels by providing evidence-based insights into practical stormwater management approaches (Johnson D. , 2019). By evaluating adherence to O.Reg. 588/17 and identifying best practices, policymakers can strengthen regulatory frameworks, allocate finances efficiently, and aid municipalities in achieving infrastructure resilience goals. (Ontario Government, 2021).

Enhancing Community Resilience:

Efficient stormwater management bolsters community resilience by minimizing disruptions caused by severe weather events and enhancing public safety. Municipalities can boost their ability to respond to climate change impacts and ensure sustainable service delivery to citizens by assessing the effectiveness of asset management plans and identifying improvement areas.

Advancing Knowledge and Practice:

The research contributes to understanding asset management planning, regulatory compliance, and urban water management. It facilitates knowledge

dissemination and fosters capacity building among municipal stakeholders by offering a comprehensive understanding of stormwater management techniques through synthesizing findings from document analysis and case studies. (El-Diraby et al., 2017).

Potential Contributions to the Study

This study aims to make significant contributions to both academic literature and practical applications:

Advancements in Research Methodology:

This study uses case study techniques, thematic analysis, and qualitative research methodologies to offer valuable insights into how these methodologies can be applied to examine complex urban infrastructure systems (Creswell, 2013).

Comparative Analysis of Techniques:

By comparing stormwater asset management plans and techniques across different municipalities, variations, similarities, and factors influencing successful implementation can be identified (Yin, 2018). This enhances our understanding of local contexts and the operational challenges in urban water management.

Policy Recommendations:

Building on the research findings, the study will propose recommendations for enhancing policy frameworks, regulatory standards, and funding mechanisms to support sustainable stormwater management. (Ontario Government, 2021).

Practical and Policy Repercussions

Helpful Information for Municipalities:

Practical and Effective Municipal Strategies (Setoodeh, 2024) highlight the potential for municipalities to glean insights from cutting-edge strategies, best practices, and comparative case studies. They posit that such an approach can drive improvements in stormwater management and inform strategic decision-making,

infrastructure development, and resource allocation.

Regulatory Conformity and Accountability:

Concerning regulatory compliance and adherence, the Government of Ontario emphasizes the importance of assessing local accountability and conformity with regulatory standards, particularly O.Reg. 588/17. They suggest that enhancing recommendations for regulatory compliance can aid municipalities in meeting infrastructure management standards and sustainability targets.

Stakeholder Engagement and Collaboration:

Moreover, (Graham, 2021) Underscores the pivotal role of stakeholder engagement, collaboration, and community involvement in stormwater management programs. By actively engaging the community, municipalities can foster partnerships, facilitate collaborative approaches, and effectively address common challenges related to urban water management.

Conclusion and Recommendations

The following excerpt summarizes the significant findings derived from the analysis of municipal asset management plans along with a comprehensive review of O.Reg. 588/17 guidelines to address the research objectives and inquiries. Additionally, this section underscores key recommendations and emphasizes the necessity for continued research endeavours in asset management planning and intergovernmental policy development.

The selected municipalities' stormwater asset management plans were effectively executed and adherent to the baseline requirements of O.Reg. 588/17. Although the municipalities largely met the core prerequisites, there was a prevalent emphasis on the requisite for enhanced data management strategies and improvement plans for future asset management plan (AMP) iterations. The document analysis revealed substantial deficiencies in the regulatory framework concerning the

interpretation and implementation thereof, as perceived by the respective municipalities. There exists ambiguity in the definition of specific requirements, thereby prompting differing interpretations among the municipalities. Moreover, the municipalities attribute the condition of the stormwater infrastructure to a physical and age-based analysis, underscoring the necessity for evidence-based condition assessment.

All sample municipalities must implement comprehensive risk-based asset planning methods. However, unlike Brantford and Hamilton, the City of Ottawa necessitates a more extensive display of risk methodologies within its AMP. Furthermore, all three municipalities reported on the levels of service framework, albeit with diverging interpretations. This divergence could potentially lead to incongruities in future policy implementation at the provincial level. There is a pressing need for enhanced training and municipal engagement to optimize service delivery, capacity, and performance. Notably, the three municipalities demonstrated the capability and possession of subject matter expertise to undertake in-house AMP development, signalling adherence to the provincial O.Reg. 588/17 since its enactment in 2017.

In Ontario, municipalities must conduct investigations into stormwater asset management to reduce the risk of flooding, maintain water quality, and ensure the durability of urban infrastructure. The Government of Ontario emphasizes the significance of regulatory frameworks in standardizing planning and promoting accountability by assessing compliance with Ontario Regulation 588/17 (Ontario Government, 2021). This research advances urban stormwater management techniques by integrating lifespan cost analysis and GIS technology. Recommendations that support community resilience and sustainability shape strategic investments and policy frameworks.

Future research must investigate how stakeholders can participate and integrate green infrastructure while monitoring implementation results. (Johnson D. , 2019) To improve urban water management methods. This proposal's main aim is to enhance the efficiency of stormwater management, which will benefit communities throughout Ontario.

Recommendations

The municipalities' chosen asset management plans have met the O.Reg.588/17 requirements. However, to enhance their practices further, they are suggested to improve by aligning with ISO 55000 and the International Infrastructure Management Manual (IIMM). Integrating these best practices with O.Reg.588/17 into municipal asset management planning can lead to more robust and comprehensive processes. This study's findings could also be an initial assessment of stormwater infrastructure asset management planning in different Ontario municipalities. These evaluations provide valuable insights that municipalities can use to refine and enhance future versions of their asset management plans, address identified gaps, and create strategies for continuous improvement.

The province needs to improve its implementation of municipal asset management planning regulations. It should better align with related rules, policies, and standards. Furthermore, higher levels should consider offering training programs and incentive models. These steps would help municipalities provide additional work, especially in cases requiring specialized knowledge or where resources are readily available. This support is crucial for smaller cities to meet regulatory demands across Ontario. Prioritizing the acquisition of climate resilience assets in long-term asset planning for municipalities is also essential.

Future Research and Studies

This report's research findings and recommendations offer an initial evaluation

for future stormwater asset management planning efforts. Municipalities can use the document's analysis to assess their performance and serve as a reference for implementing other municipalities. The province of Ontario can use these results to identify deficiencies in policy establishment procedures and, notably, improve ongoing Asset Management Plan (AMP) regulations. Furthermore, the study highlights the importance of harmonizing infrastructure planning regulations with intergovernmental frameworks to ensure timely support for municipalities dealing with funding and resource difficulties. It is essential for higher levels of government to thoroughly evaluate policy implementation before distributing them to municipal governments. Concerns about the timing and significance of policy implementations have been raised.

This study used document analysis to compare randomly chosen municipalities' Asset Management Plan (AMP). It is essential to evaluate future iterations of the AMP from these municipalities further to measure their progress in managing stormwater assets. According to O.Reg.588/17 requirements, municipalities must update their asset management plans and undergo council reviews to track progress. They must also conduct a comprehensive five-year review and submit the findings to the province. Therefore, upcoming research and studies should emphasize the enhancement of provincial guidelines and asset management criteria by comparing them with the previous AMP of the selected municipalities. In addition, the province should explore integrating international asset management standards and industry best practices in the next update of O.Reg.588/17. The O.Reg.588/17 is a promising first step toward standardizing and promoting effective implementation of asset management in Ontario's municipal infrastructure management. Other provinces and territories must consider implementing similar regulations, learning from Ontario's experience, and ensuring that local municipalities

adhere to well-designed processes for infrastructure planning.

Effective asset management practices can be the primary strategy for facilitating informed decision-making by municipal leaders, promoting good governance, increasing accountability, and ensuring accurate forecasting of infrastructure replacement, renewal, and long-term sustainability of municipal stormwater assets and other infrastructure across Canada. Adopting robust asset management planning, like the O.Reg.588/17, across municipalities in Canadian provinces can help achieve these goals. The regulation for asset management planning establishes the essential guidelines for municipal infrastructure planning and policy. In Ontario, the following stages of asset management planning include adopting superior practices in managing stormwater infrastructure and other asset categories like water, wastewater, roads, and bridges.

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Appendix A : Asset Management Plans and O. Reg. 588/17 Weblink

- City of Hamilton Stormwater Asset Management Plan
- City of Brantford Stormwater Asset Management Plan
- City of Ottawa Stormwater Asset Management Plan
- O. Reg. 588/17: ASSET MANAGEMENT PLANNING FOR MUNICIPAL INFRASTRUCTURE