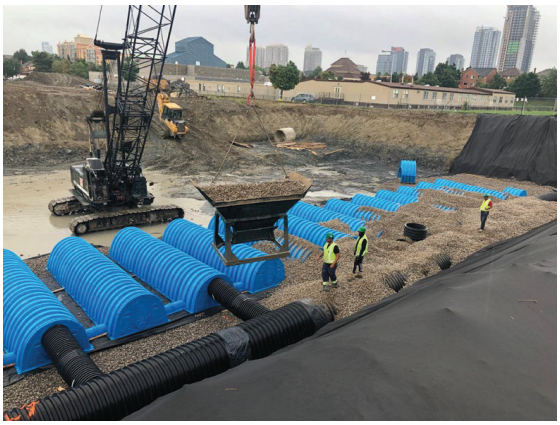

NON-CONVENTIONAL STORMWATER MANAGEMENT FACILITIES
BACKGROUND REPORT
Final Submission

2023-001
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Executive Summary

Resilient Consulting Corporation ('Resilient') has been retained by the City of Vaughan (the 'City') to develop a policy, procedure, and relevant design criteria/standards for the approval of non-conventional municipal stormwater management facilities ('SWMFs') associated with new development. The City, along with many neighbouring municipalities, is experiencing increased pressure to shift from requiring conventional SWMFs (i.e. wet/dry ponds) to accepting publicly owned and operated non-conventional SWMFs (i.e. underground tanks, superpipes, etc.). These facilities can be incorporated below new public parklands or below right-of-ways, as the underground feature allows for dual purpose of the land above. At the time of development of this report, approval of non-conventional SWMFs has largely been completed on a case-by-case basis with considerations for feasibility, maintenance and operation requirements, and site-specific design constraints. An interim approach for accepting these facilities was adopted by the City in 2022, however the goal of this project is to develop a new formal policy, procedure, and design criteria for accepting non-conventional SWMFs. The primary objectives in developing this framework are:

- To provide a decision framework to determine where new non-conventional SWMFs may be accepted;
- To streamline the evaluation and acceptance process for non-conventional SWMFs;
- To provide a list of allowable stormwater management technologies/facility configurations that can be accepted as municipal facilities; and,
- To examine financial implications and lifecycle costs of implementing non-conventional SWMFs vs. conventional facilities and develop cost recovery mechanisms to be apply to subject developments to ensure implementation of non-conventional SWMFs are financially viable alternatives in the long-term.
- To create a standard operating procedure (SOP) that outlines the inspection, operation and maintenance protocols for the non-conventional SWMFs to ensure the long-term success of implementation.

The City of Vaughan, and other regulatory agencies have various existing policies, procedures, guidance documents, and established criteria for the approval of stormwater management facilities, including but not limited to; City of Vaughan *MECP's CLI-ECA for Municipal Stormwater Management Systems* (2022), MECP *Draft Low Impact Development Stormwater Management Guidance Manual* (2022), City of Vaughan *Engineering Design Criteria & Standard Drawings* (2020), TRCA *Stormwater Management Criteria* (2012), and *CVC/ TRCA Low Impact Development Stormwater Management Planning and Design Guide* (2010). These documents provide regulations and design criteria in relation to the approval of conventional SWMFs, and do not explicitly reference the design requirements of non-conventional SWMFs. In 2022, the City adopted an interim approach to approving non-conventional SWMFs which detailed the financial contribution required by the developer to compensate for an increase in cost when compared to conventional SWMFs, in addition to providing some general limitations and considerations when preparing the facility design. At the time of its development, no other municipality within the Greater Toronto Area ('GTA') had created a formal overall approval policy for the acceptance for non-conventional SWMFs. A thorough review of the City's existing policies and programs has been conducted as a part of this report to identify relevant guidelines and restrictions that should be taken into consideration during the preparation of the City's formal policy, procedures and standards for non-conventional SWMFs, ensuring consistency across the City's planning and development policies.

In addition, six (6) municipalities across Ontario were contacted to confirm if any policies, procedures, design criteria, or standards have been implemented for non-conventional SWMFs within their jurisdiction. The following is a list of the contacted municipalities:

- City of Markham, Ontario
- City of Mississauga, Ontario
- City of Richmond Hill, Ontario
- City of Hamilton, Ontario
- City of Burlington, Ontario
- City of Kitchener, Ontario

Upon review of this collected information, it was confirmed that, with the exception of the City of Markham, the remaining neighbouring municipalities do not currently have any specific policies or guidelines in place to address the approval of non-conventional SWMFs.

There are many potential advantages to implementing a non-conventional SWMF, including but not limited to: providing a dual-purpose to the land (ie. not just SWM pond), requires a smaller at-surface footprint, eliminates at-surface water quality concerns such as standing-water and E.Coli contamination from wildlife, can be designed to accommodate both passive and active programming of the space above the facility or other dual utilitarian usage such as parking and roads, lowers water temperature of discharge, and improves safety by eliminating the potential of drowning and/or falls through ice. Apart from these benefits, there are many applications that cannot accommodate the required area for a dry/wet pond. As such, it is acknowledged that non-conventional SWM facilities may have advantages as opposed to conventional dry/wet ponds in locations with restricted available area.

Non-conventional SWMFs may also have disadvantages in comparison to traditional SWM ponds. These disadvantages may include:

- Reliance on engineered products with design lives of 50 to 100 years to achieve volume requirements, instead of open excavated ponds;
- Limitations on monitoring and inspections associated with confined space entry requirements;
- Elevated frequency and complexity of the maintenance and inspection of system;
- Potential presence of odour due to improper maintenance;
- Potential for significant failure or loss of storage volume through clogging if routine maintenance of pre-treatment devices is not carried out; and,
- Significant impact to park facilities and programs for major repairs and lifecycle replacement.

To support the project objective of defining a list of acceptable technologies, a detailed review of common non-conventional SWMFs was completed to assess the feasibility of each option, operation and maintenance requirements, specific advantages/disadvantages, and limitations for each facility, and estimate capital and lifecycle costs. The following non-conventional SWMFs have been assessed:

- Plastic "Milk-Crate" Systems;
- Plastic Arch Chamber Facilities;
- Modular Concrete Chambers;
- Superpipes;
- Cast-in-place Concrete Facility; and,
- Modular Form Cast-in-place Systems.

Various limitations were defined for each of the non-conventional SWMFs type examined, ranging from standard height sizes and required burial depths for many of the pre-cast systems, winter weather conditions and anticipated delays for the cast-in-place systems, and delivery considerations for

superpipe systems to ensure safe passage under bridge overpasses. Similarly, specific requirements such as load bearing capacity, separation from groundwater elevations (for infiltration facilities), and minimum cover need to be considered when selecting a preferred SWMF. Lastly, consultation with the City's operation and maintenance department is required prior to finalizing the acceptable list of technology to discuss the requirements of the preferred system and ensure proper equipment, staff training, and external services are available to complete the required maintenance.

A lifecycle assessment was completed as a part of this report to compare the financial implications associated with each of the common non-conventional SWMFs outlined above. The lifecycle assessment of these facility types found that the modular form cast-in-place systems resulted in the lowest capital cost investment, and ultimately lowest lifecycle cost as a result of its long-life expectancy (100-years). Although these costs are the lowest, this system has the highest maintenance costs, and has many limitations and considerations associated with construction. Superpipe facilities were noted as the most expensive option upfront and may not be best suited for large storage volume applications due to this associated cost.

Upon completion of the Background Report, stakeholder engagement sessions will be arranged to review and discuss the results of the report, in addition to providing opportunities for internal and external stakeholders to provide feedback on their concerns associated with the current interim approach for accepting non-conventional SWMFs. A technical review of the City's existing sixteen (16) non-conventional SWMFs will then be completed prior to proceeding with Stage 2 of the project.

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1 Introduction

The implementation of effective stormwater management is critical in mitigating the undesirable impacts of urbanization on the natural hydrologic cycle and on local watercourses and associated infrastructure. Stormwater management (SWM) infrastructure has been installed in the City of Vaughan ('City') since the early 1980s, with the City currently owning and operating 147 conventional stormwater management facilities ('SWMFs'). Conventional stormwater management ponds are a common approach for addressing stormwater management requirements within a new development, however a significant amount of developable land is required to implement these facilities. The increased demand for housing and high value of land has resulted in developers looking for alternative options for publicly owned and operated SWMFs. To date, the City has approved or is in the process of approving 16 non-conventional SWMFs, which have been reviewed and considered on a case-by-case basis taking into consideration acceptability, feasibility, maintenance, and operation requirement for each application. These non-conventional SWMFs are under roadways, passive open space blocks and within parks. These approved facilities have included underground stormwater tanks and superpipe storage. Due to the higher total cost of ownership for these non-conventional SWMFs, the City has also required a one-time cost contribution from the developer, calculated on a case-by-case basis, ensuring the financial cost differential between operation, maintenance, and replacement of conventional and non-conventional SWMFs is secured.

In June 2022, an interim approach for accepting non-conventional SWMFs was adopted by City Council to address the increased pressure for approval of innovation stormwater solutions from local developers. One of the recommendations of the Council Report suggested the City retain a consulting engineering firm to develop of a formal policy and procedure for reviewing and accepting non-conventional SWMFs. As a result, Resilient Consulting Corporation ('Resilient') was retained by the City to prepare a City Policy, Procedure, and Engineering and Parks Design Criteria for non-conventional SWMFs, thereby addressing the City's needs for evaluating, accepting, implementing and maintaining non-convention SWMFs. These new documents will strictly apply for publicly owned and maintained infrastructure, and will not apply for non-conventional SWMFs proposed on private lands.

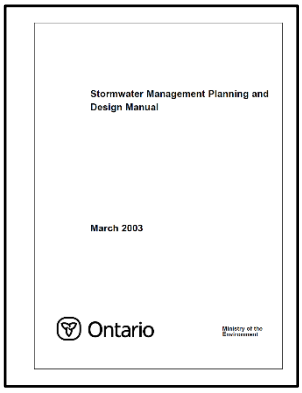
To facilitate the development of this new policy, procedure, and design criteria, the following comprehensive background review was prepared by Resilient to assess the City's current interim approach for accepting non-conventional SWMFs and to identify any design consideration, constraints and data gaps that should be taken into consideration during the preparation of the new design framework. Relevant background reports reviewed as a part of this report are provided in **Appendix A.**

2 Existing Policy and Procedure Review

As with all municipalities in Ontario, the City of Vaughan must operate according to planning and policy framework that has been developed to support provincial, regional and local objectives in growth. All new City policies and procedures must ensure that the final recommendations are consistent with these provincial, regional and local policies and objectives.

The following sections provide a review of these existing documents that may be applicable during the development of the new City of Vaughan policy, procedure and design criteria for non-conventional SWMFs.

2.1 MECP Stormwater Management Planning and Design Manual, March 2003



The MECP Stormwater Management Planning and Design Manual provides technical and procedural guidance for the planning, design and review of stormwater management practices. The manual provides practical guidance for specific circumstances and encourages the development of innovative designs and technologies for stormwater management outside of what is specified within the manual. Design guidance is provided for individual lot level, conveyance and end-of-pipe practices, taking into consideration physical constraints such as soil type and groundwater conditions, climate considerations, restoration, maintenance and financial implications.

The manual is divided into the following key sections:

- Environmental Planning;
- Environmental Design Criteria;
- Stormwater Management Plan and SWMP Design;
- Infill Development;
- Operation, Maintenance and Monitoring; and,
- Capital and Operational Costs.

Chapter 4 of the manual focuses specifically on the design and implementation of a stormwater management plan to meet all local criteria for water balance, water quality, erosion and water quantity controls. Various lot level controls, including rooftop storage, superpipe storage, infiltration trenches, and pervious pipe systems are identified within the manual to reduce peak runoff rates and promote onsite infiltration, ultimately reducing end-of-pipe storage requirements. However, these controls typically require implementation on lands held in private ownership, with maintenance and effectiveness of the system contingent on the actions of the landowners.

The end-of-pipe SWMFs identified within the manual include:

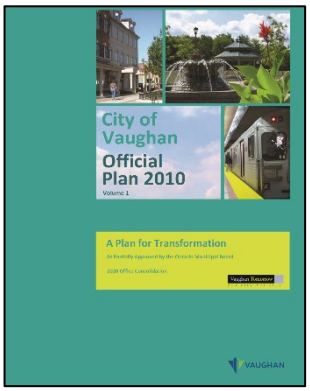
- Wet ponds;
- Wetlands;
- Dry ponds; and,
- Infiltration basins.

Detailed design criteria for the development of these conventional end-of-pipe facilities, include treatment volume requirements, forebay depth, side slopes and retention times are provided within the manual, in addition to various equations that can be utilized to determine specific design parameters.

Chapter 6 and Chapter 7 of the manual focuses on the operation and maintenance requirements, and financial implications associated with the implementation of these urban stormwater solutions. Approximate unit costs for capital construction and commonly required maintenance activities, such as grass cutting and the flushing of pipes, are provided based on industry standard pricing from 2003.

The MECP Stormwater Management Planning and Design Manual does not provide design criteria or guidance in relation to non-conventional end-of-pipe SWMFs, such as underground arch chambers systems or concrete facilities. The manual does provide some guidance on the use of superpipes to provide subsurface storage and reduce peak flows, however this is examined as a lot level control only, as superpipes must be implemented within a treatment train in order to provide the required water balance, water quality, and erosion control requirements.

2.2 City of Vaughan Official Plan 2010 and Update



The City of Vaughan 2010 Official Plan ('OP') addresses the City's long-term planning requirements to the year 2031 and, in addition to consolidating all former land use policies into one document, the Plan brings the City into conformity with recent provincial and regional land use policy direction. The OP is part of an overall Growth Management Strategy, initiated by Council, that will shape the future of the City and guide its continued transformation into a vibrant, beautiful and sustainable City.

The goals of the Official Plan are as follows:

- Goal 1: Strong and Diverse Communities;
- Goal 2: A Robust and Prominent Countryside;
- Goal 3: A Diverse Economy;
- Goal 4: A Vibrant and Thriving Downtown;
- Goal 5: Moving Around without a Car;
- Goal 6: Design Excellence and Memorable Place;
- Goal 7: A Green and Sustainable City; and,
- Goal 8: Directing Growth to Appropriate Locations.

The above goals constitute the City of Vaughan's Vision for Transformation and were developed following extensive consultation with Vaughan residents to define the main principles that would guide the development of the OP.

Policy 3.6.6 (3.6.6.1. – 3.6.6.17.) of the OP provides direction on stormwater management in the City of Vaughan. Given the extensiveness of the Policy, a summary of the main points is provided below:

- To recognize stormwater management facilities as a functioning part of Vaughan's natural water system and ecosystem, new development will employ stormwater management practices that are sensitive to the natural environment and natural heritage features.
- That new development must satisfy the City and demonstrate consistency with the TRCA Stormwater Management Criteria for water quantity (flood flow) control, water quality control, erosion control, groundwater recharge and water balance, for the protection of hydrologically sensitive features.
- Consideration of innovative stormwater management approaches must be implemented and designed in accordance with MECP's Stormwater Management Practices Planning and Design Manual and with reference to TRCA's LID Stormwater Management Planning and Design Guide.
- New stormwater facilities shall be:
    - located outside of valley and stream corridors, unless approved by TRCA and MECP;
    - located, where possible, adjacent to open spaces, parks and/or natural heritage areas contributing to a connected system and to encourage public access to these facilities, where appropriate;
    - integrated into surrounding developments as publicly accessible open space; and,
    - designed as naturalized or formal landscapes that are complementary to adjacent features, including adjacent landscapes or natural heritage features.
- Undertake stormwater management on a volume control basis that maintains recharge rates, flow paths and water quality to the extent possible, in addition to peak flow control, and to maintain pre-development water balance. Particular emphasis shall be placed on areas confirmed as significant recharge areas.

- To support the TRCA in establishing programs for ongoing monitoring of ambient conditions as part of the Regional Watershed Monitoring Program, including evaporation, stream flow, channel form, groundwater levels, water quality and terrestrial communities and species to provide baseline data to facilitate an adaptive management approach.

As summarized above, the 2010 OP encourages the implementation of innovative stormwater management approaches where appropriate, however these designs must remain in accordance with guidelines set forth by the MECP and TRCA. At this time, the MECP and TRCA have yet to implement regulations specific to non-conventional SWMFs. The OP also emphasizes the need for new SWMFs to be designed as publicly accessible facilities located adjacent to open spaces, parks or natural heritage areas.

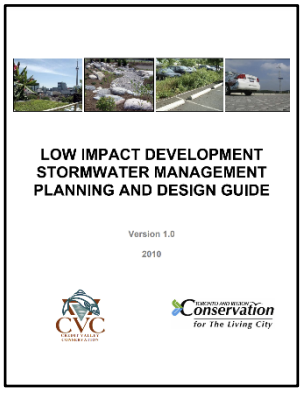
Policy 7.3 of the OP also provides detail related to parks and open spaces within the City of Vaughan, which require consideration during the implementation of non-conventional SWMFs under parkland. Parks and open space design requirements, including park size, recreational uses, and orientation will impact the feasibility of constructing underground stormwater infrastructure within these spaces.

The City of Vaughan is currently in the process of completing an Official Plan Review to guide the City's growth for the next 30 years and beyond. As a component of this review, the City has prepared seven background reports which summarize research, best practices, and feedback received from the community regarding their hopes for Vaughan in the future. The following background reports were prepared in 2022 to provide recommendations for development of future Official Plan policy:

- Agricultural System Review;
- Residential Growth, Intensification and Housing Needs Strategy;
- Employment Land Use Review;
- Climate Change Adaptation and Resilience Framework;
- Commercial Land Use Review;
- Natural Heritage Network Review; and,
- Urban Design, Built Form, Compatibility and Sustainable Development.

The prepared background reports provide an overview of existing policies and regulations in place across Canada related to the various areas of interest, in addition to providing strategic recommendations for updating the existing 2010 City of Vaughan OP. The application of non-conventional SWMFs is not directly identified within the available background reports, however policy recommendations include encouraging the incorporation of innovative and low impact stormwater management practices and green infrastructure where feasible.

2.3 CVC/ TRCA Low Impact Development Stormwater Management Planning and Design Guide, 2010



The CVC/TRCA Low Impact Development Stormwater Management Planning and Design Guide was developed by Credit Valley Conservation ('CVC') and the TRCA to provide direction on landscape-based stormwater management planning and LID best management practices for development within the CVC and TRCA watersheds. The guide provides direction on the selection, design, construction, and monitoring of these landscaped-based stormwater management strategies, with particular focus on the planning and design of structural low impact development practices.

The guide provides the key principles in the design of LIDs as follows:

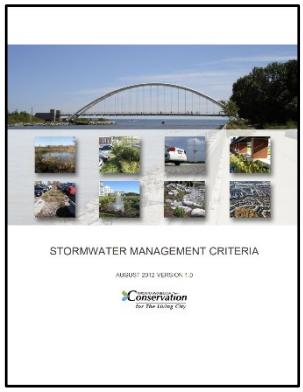
- Use existing natural systems as the integrating framework for planning;

- Focus on runoff prevention;
- Treat stormwater as close to the source as possible;
- Create multifunctional landscapes; and,
- Educate and maintain.

LID practices, applied within a treatment train approach with end-of-pipe facilities, were noted to provide increased runoff reduction, be more cost effective, have lower maintenance burdens, and be more protective of aquatic habitat than stand alone end-of-pipe facilities.

2.4 TRCA Stormwater Management Criteria, August 2012

The Toronto and Region Conservation Authority ('TRCA') Stormwater Management Criteria provides current design guidelines and requirements related specifically to stormwater management within the TRCA's jurisdiction, building upon the TRCA Planning and Development Procedural Manual (2007) that outlines the general requirements when seeking development approval by the TRCA. This document is intended to provide guidance to developers, consultants, municipalities and land downers during the planning and design of stormwater management infrastructure, outlining the requirements to achieve flooding, water quality, erosion, water balance and natural heritage standards. The primary stormwater management design criteria required by the TRCA is as summarized below:

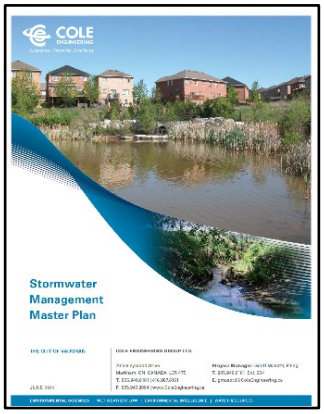


- **Stormwater Quantity**: Control peak flows to the appropriate watershed flood control criteria.
- **Erosion:** At minimum, retain 5mm on site where conditions do not warrant the detailed analysis. For sites with SWM ponds, 25mm – 48 hr detention may be required based on the completion of an erosion assessment.
- **Stormwater Quality:** Achieve Enhanced Level of Protection (80% TSS removal) and mitigate thermal and bacteriological impacts.
- **Water Balance:** For Low Volume Groundwater Recharge Area, implement best efforts to maintain recharge. For Significant, Ecologically Significant, and High Volume Ground Recharge Areas, a site specific water balance analysis and recharge is required. For natural features, maintain the hydrologic regimes.

This criteria is presented as the minimum requirements when preparing a stormwater management plan, however this criteria may not apply where a comprehensive environmental study has been completed and approved, and where the study has established refined criteria based on a location specific technical analysis.

With regards to the SWM practices that may be accepted by TRCA, the document refers to both the MECP Stormwater Management Planning and Design Manual (2003) and the TRCA/CVC Low Impact Development Stormwater Management Planning and Design Guide (2010) to outline infrastructure that may be utilized in the development of a SWM strategy. Conventional SWMFs, including SWM ponds, wetlands, oil and grit separators ('OGS') and LID practices are referenced throughout the document, however it was noted that the TRCA encourages the implementation of innovative designs and green infrastructure, provided the proposed works also satisfy all applicable requirement and criteria set forth within the document.

2.5 City of Vaughan SWM Master Plan Class EA Study, 2014



The City's Stormwater Management ('SWM') Master Plan Class EA evaluates the effectiveness of the existing SWM infrastructure within the City. The study evaluated the use of alternative SWM practices for effective treatment of stormwater from source, conveyance, and end-of-pipe controls, to promote protection of the natural environmental systems and was conducted in accordance with the Master Plan process as outlined in the Municipal Engineers Association Municipal Class EA guidance (October 2000, as amended in 2007 and 2011).

To support the overall study objective of determining the Best Management Practices ('BMPs') for SWM in support of future intensification with the City, the following three alternatives were identified for evaluation:

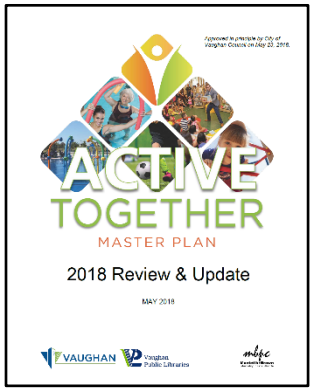
1. Do nothing;
2. Lot level/ at source/ conveyance controls; and,
3. End-of-pipe measures.

The "Do Nothing" alternative identified within the Class EA was noted to not require any action by the City, however no SWM strategy would be provided for future development and this approach would not meet the environmental objectives of the City's SWM practices. The implementation of lot level/ at source/ conveyance level controls were considered "small scale" controls for meeting SWM design criteria, and may include implementation of the following:

- Roof Downspout Disconnection;
- Bioretention;
- Green Roofs;
- Soakway Pits, Infiltration Trenches, and Chambers;
- Permeable Pavement;
- Rainwater Harvesting;
- Rooftop Storage;
- Parking Lot Storage;
- Underground Storage;
- Grassed Swales;
- Perforated Pipe System;
- Vegetated Filter Strips; and,
- Oil/ grit Separators.

End-of-pipe measures identified within the Class EA consisted of wet ponds, dry ponds and constructed wetlands. The alternatives were evaluated on a Secondary Plan basis, with the preferred SWM strategy for each area including a combination of lot level, conveyance and end-of-pipe controls. The recommendation of non-conventional stormwater infrastructure, including underground storage facilities remained limited to small scale applications at the lot level, and were not considered for end-of-pipe SWMFs. The use of underground storage was recommended as a part of the overall treatment train approach for Younge Steeles Secondary Plan area, Woodbridge Core Secondary Plan area, the West Vaughan Employment area, Huntington Road Community, Vaughan Mills Centre, Concord Centre, the Vaughan Health Campus of Care, Dufferin St./ Centre St. area and the Promenade Mall.

2.6 City of Vaughan Active Together Master Plan 2018



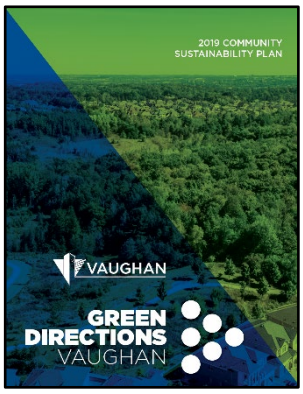
The 2018 City of Vaughan Active Together Master Plan ('ATMP') Update guides the provisions of parks and open space, recreation and library facilities within the City to the year 2031, providing an assessment of current levels of service and delivering recommendations on both policy and infrastructure requirements for this period. The 2018 ATMP Update contains 103 recommendations intended to guide municipal and community investments in parks, recreation, and library facilities. An implementation plan has been included within the recommendations, however successful implementation is noted to be highly dependent upon a variety of factors including funding, partnerships and land availability.

Recommendation #4 for the ATMP applies to the acceptance of open space lands as dedicated parkland space. As outlined in the ATMP, open space lands is defined as sites with no to low development potential, which may include land used for conventional stormwater management infrastructure. The ATMP recommends that undevelopable open space lands not be accepted as a part of the parkland dedication requirements set forth by the City. The City may assume these lands through voluntary dedication or easement, however no credit will be applied to the developer.

Recommendation #12 of the ATMP encourages the implementation of non-traditional parks and open spaces in areas of intensification and recommends the establishment of standards to provide guidance on how these are to be implemented. Specifically, the recommendation references the need to work with the development industry to identified alternative park space options to supplement prescribed parkland dedication requirements. This may include the application of strata parks, which in the context of parks and recreation refers to public spaces that are developed on underground stormwater infrastructures, parking garages or other roof slab constructions.

Based on the recommendations summarized above, the ATMP supports the City's current effort to establish standards for non-traditional parks and open spaces located above non-conventional stormwater infrastructure (strata parks) in areas of intensification, which may be able to supplement required parkland dedications required by the developer. Conventional SWMFs located in open space lands are recommended to not be acceptable as a part of parkland dedication, therefore requiring developers to utilize additional developable land to meet these parkland dedication requirements.

2.7 City of Vaughan Green Directions Vaughan, 2019



Green Directions Vaughan ('GDV') was first approved by Council in 2009 as the City's Community Sustainability and Environmental Master Plan, and most recently underwent an update in 2019. The Plan outlines the sustainable priorities of the City and provides actions to aid the City in maintaining a healthy natural environment, vibrant communities and a strong economy. The Plan provides guidance on achieving a more sustainable future by addressing environmental, cultural, social and economic values.

The following six (6) primary goals are outlined within the Plan:

1. To significantly reduce waste and the use of our natural resources.
2. To ensure sustainable development and redevelopment.
3. To ensure that the City is easy to get around with a low environmental impact.

4. To create a vibrant community where citizens, business and visitors thrive.
5. To be leaders in advocacy and education on sustainability issues.
6. To ensure a supportive system for the implementation of GDV.

The GDV provides a number of key objectives for each goal, which are further supported by the development of sustainability actions that can be implemented by the City to achieve these goals. These sustainability actions act as quantitative indicators that are critical in tracking the progress of achieving these overall goals within the next five (5) years.

Objective 1.3 of the GDV provides direction to the City on stormwater management and water conservation as it relates back to the primary goal of significantly reducing waste and the use of our natural resources. The objective identifies the need for the City to support enhanced standards of stormwater management and water conservation at City facilities, and to work with others to care for Vaughan's watersheds.

Sustainability actions identified under this objective include:

- Identify best management practices to minimize salt use on hard surfaces and protect receiving watercourse from salinity increases;
- Establish a water quality monitoring program for stormwater management assets;
- Identify stormwater management initiatives to protect and regenerate key watershed functions including the regulation of water quantity, the regulation of water quality and temperature, sediment and erosion control, hydrologic connectivity and habitat provisions. Stormwater management will be informed by watershed planning and long-term land use planning and development forecast;
- Integrate climate change considerations into guidelines for flood control and stormwater management;
- Continue to work with York Region in support of water conservation;
- Encourage low impact development and a treatment train approach to stormwater management through the development review process and by implementing and monitoring stormwater rate program, including the technical and community engagement aspects and innovative pilot initiatives; and,
- Improve tracking of potable water use at the City facilities to identify conservation opportunities and best practices, and in conjunction with he corporate energy management strategy.

Non-conventional SWMFs are not specifically identified within the GDV, however innovative approaches to enhancing stormwater management within the watershed are encouraged.

2.8 City of Vaughan Engineering Design Criteria & Standard Drawings, 2020

The City of Vaughan Engineering Design Criteria and Standard Drawings ('EDCSD') provides guidance to those engaged in the design and construction of municipal infrastructure within the City of Vaughan. The EDCSD provides criteria and standard drawings for a range of municipal projects, including but not limited to municipal infrastructure, lot grading and site development. Section 1.3 of the EDCSD provides specific design considerations as it relates to stormwater management, which have been further subdivided into the following sections:

- General Design Considerations;
- Storm Sewer System Design;
- Testing and Inspection;

- Decommissioning;
- Stormwater Management Facilities; and,
- LID Practices.

As per the EDCSD, the implementation of end-of-pipe SWMFs are typically considered only for developments greater than five (5) hectares, where the application of lot level controls is considered impractical. Design criteria within the document is limited to conventional SWMFs, with criteria provided for the design of emergency overflows, outfalls, spillways, plantings and safety measures for conventional stormwater ponds. The EDCSD does not provide design criteria or standard drawings for non-conventional SWMFs.

As part of future phases of the current project, Resilient will be responsible for developing design criteria and engineering standards for non-conventional SWMFs. The developed information will be included in a future version of the EDCSD.

2.9 MECP Low Impact Development Stormwater Management Guidance Manual (Draft), January 2022

The Low Impact Development Stormwater Management Guidance Manual, published in draft by the MECP for public review in January 2022, provides performance guidance for stormwater management specifically related to the implementation of Low Impact Development ('LID'). LID is defined within the manual as a stormwater management strategy, system or facility that seeks to mitigate the impacts of increased runoff and stormwater pollution by managing runoff close to its source. Implementation of LIDs employ small scale site design strategies to mimic the natural water cycle through the process of infiltration, evapotranspiration, harvesting, filtration, detention, and reuse. The manual offers information that is complimentary to the 2003 MECP Stormwater Management Planning and Design Manual and the 2008 Design Guidelines for Sewage Works, providing guidance on implementation of a holistic treatment train approach for stormwater management within Ontario.

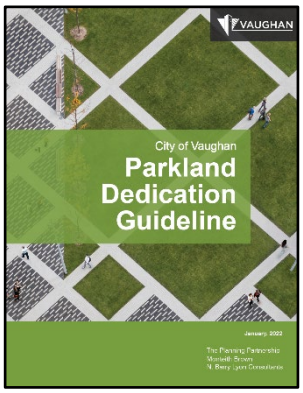
In addition to providing guidance and criteria on the design, construction and operation of LIDs, the manual also provides guidance for achieving the runoff volume control target (90th percentile precipitation event) for new development, re-development, linear development, and stormwater retrofits within Ontario.

All performance guidelines provided in the manual are limited to lot level, at the source, and conveyance controls, however design guidance for end-of-pipe treatment is excluded from the document. As a result, the LID SWM Guidance Manual is of limited benefit in providing direction of the design and implementation of end-of-pipe dual use SWMFs.

2.10 City of Vaughan Parkland Dedication Guideline, January 2022

The City of Vaughan Parkland Dedication Guideline offers guidance on the parkland dedication and acquisition process, providing key considerations to assist in the implementation of a revised approach to address increased pressure for acceptance of alternative parkland spaces. The document was primarily developed to serve as a comprehensive guideline used for the development of a future

Parkland Dedication By-Law. At the time of the preparation of the guideline, the City did not have a Parkland Dedication By-Law in place. A Cash-in-Lieu By-Law, last updated in 2012, was used to impose parkland/payment-in-lieu conditions through the development process, however a new Parkland Dedication By-Law was noted to be required by September 18th, 2022.



A total of fifty-four (54) considerations are provided within the guideline, with input ranging from the amount of gross land area that should be required as parkland to administrative elements for the implementation of the new by-law. Consideration #46 provides input on the dedication of parkland for conventional stormwater management facilities, recommending that lands required to accommodate these SWMFs not be accepted for dedication. In relation to non-conventional SWMFs, the guideline considers opportunities of parkland dedication for strata parks, where the City is provided ownership of parkland located over the top of an underground structure or facility such as a SWMF. The guideline recommends that the land area of a strata park should be counted toward the required parkland dedication, but the actual amount of land counted may be discounted to reconcile issue related to lifecycle costs and lifespan of these facilities.

2.11 City of Vaughan MECP's CLI-ECA for Municipal Stormwater Management Systems, April 2022

The Environmental Compliance Approval for a Municipal Stormwater Management System was issued to the City of Vaughan by the Ministry of Environment, Conservation and Parks ('MECP') on November 25th, 2022, in accordance with the Environmental Protection Act (1990). The approval covers the entire municipal stormwater management system owned and operated by the City, which is classified as a separate system from all sanitary systems located within city limits. The approval also covers stormwater management systems located on private lands that are considered a part of the municipal stormwater treatment train, including infiltration trenches, swales and rear lot catch basins located at seven (7) different sites within the city.

A total of 245 stormwater management facilities and pumping stations are authorized under the ECA, which are broken down into the following facility types:

- 119 Stormwater Management Ponds – Wet (Including wetlands, hybrids)
- 26 Stormwater Management Ponds – Dry
- 19 Super Pipe/ Storage Facilities
- 28 Sedimentation MTD – OGS
- 1 Pumping Station

An additional thirty-nine (39) facilities are identified within the ECA to be connected to the municipal stormwater management system; however, ownership of these facilities have not been assumed by the City, and separate ECAs are required for these facilities.

In addition to providing details on each authorized facility, the ECA outlines acceptable future alterations to the system, stormwater management criteria, inspection and monitoring requirements, and annual reporting needs.

2.12 Vaughan Sustainability Metrics Program, May 2022

The Sustainability Metrics Program, developed in partnership by the Cities of Brampton, Markham, Richmond Hill and Vaughan, is a point-based system implemented as a part of the development application process to encourage sustainable performance of new developments. As a component of the application submission, development proposals are required to achieve a minimum sustainability scores dependent on the type of planning application. The Sustainability Metric is organized into the following categories:

- Built Environment (BE);
- Mobility (MB);
- Natural Environment and Parks (NE);
- Infrastructure and Buildings (IB); and,
- Innovation (IN).

The Natural Environment and Parks category provides opportunities for points related to the implementation of stormwater infrastructure. Specifically, additional points are awarded for retaining increased runoff volume on site (NE-9), for providing advanced quality controls (NE-10), and for enhancing the public use values of stormwater management facilities through the installation of beautification measures around SWM ponds (NE-12). At this time, there are no point opportunities strictly related to the implementation of non-conventional SWMFs.

2.13 City of Vaughan Parkland Dedication By-Law 168-2022, June 2022

The Parkland Dedication By-Law 168-2022 was passed by Council on June 28th, 2022 following completion of the Parkland Dedication Guideline in January 2022. The By-law includes provisions to allow the City to continue to retain the ability to require that land be conveyed for park or other public recreational purpose as a condition of development, with the amount of land determine by applying an 'alternative rate' of parkland provision. The following key elements were included:

- Updated definition for compatibility with other City documents;
- Updated list of exempt categories;
- Clarity and expansion of lands acceptable for conveyance and parkland credit;
- Provisions for off-site land dedication;
- Updated phased-in fixed unit dates for payment-in-lieu; and,
- Transition provisions.

Parkland dedication for non-conventional SWMFs is addressed in Section 3 (2) of the By-law, which states the City is willing to accept full (100%) credit towards satisfying the parkland dedication requirements for development or redevelopment of strata parks, and land encumbered by underground SWMFs, utility coordinators and other publicly owned infrastructure. As per Section 3 (3), to achieve full credit the City and the owner must enter an agreement that the land for dedication:

A. Is permit-ready for active and/or passive park programming;
B. Is designed and developable to City standards;
C. Does not prohibit or restrict public programming;
D. Will be open and accessible to the public at all times;
E. Meets applicable criteria of City's OP; and,

F. Meets requirements of Greenbelt or Oak Ridges Moraine policies.

Conventional SWMFs, such as stormwater ponds, will not be acceptable for parkland dedication, as detailed under Section 3 (5).

2.14 City of Vaughan Committee of the Whole (Working Session) Report, June 2022

The City of Vaughan Committee of the Whole Report, dated June 8th, 2022, provides a status update on the City's current interim approach for reviewing and accepting non-conventional stormwater infrastructure implementation and the associated financial contribution that is required to offset the additional costs of this infrastructure once it has been assumed by the City. The Report highlights the need for the development of a formal policy and procedure for accepting non-conventional SWMFs, as current approvals are completed on a case-by-case basis. At this time, no other municipality within the Greater Toronto Area ('GTA') has created a formal approval policy for the acceptance for non-conventional SWMFs or provided requirements for financial contributions from developers to operate these facilities on public lands. The exception to this is the City of Markham, who requires a one-time payment by the developer for the cost differential between operation, maintenance, rehabilitation and replacement cost of a conventional SWMFs compared to alternative infrastructure based on a 50-year lifespan.

The interim approach applied by the City is noted to be effective in ensuring stormwater management is achieved, however it does not take into consideration important social, economic and environmental factors and the overall integration of these non-conventional SWMFs within future communities. As a result, the City is in need of a formal policy that will ensure all development and planning matters are considered during the approval process.

The Report also provides a brief overview of the submission and review process of a dual-use SWMFs policy paper submitted in January 2022 by Malone Given Parsons. The policy paper focuses on opportunities to implement underground stormwater storage within future City parks for land use efficiency and to allow for more development areas. The City retained WSP Canada ('WSP') to complete a peer review of the policy paper, with WSP noted to be in general agreement with the findings of the report. Recommendations regarding technical design requirements, and the need for further research into the financial implications of dual-use SWMFs were provided by WSP. Results of this peer review were incorporated into the development of the interim policy and are to be taken into consideration during the development of the formal policy and procedures for approval of non-conventional SWMFs.

2.15 Existing Policy and Procedure Review Summary

The following table provides a summary of the reviewed policies and procedures as they related to the implementation of non-conventional SWMFs within the City of Vaughan.

Table 1. Summary of Existing Policies and Procedures Input on Non-Conventional SWMFs

Existing Policy/ Procedure/ Guideline	Relevance to Implementation of Non-Conventional SWMFs
MECP Stormwater Management Planning and Design Manual, March 2003	• The manual does not provide design criteria or guidance in relation to non-conventional end-of-pipe SWMFs. • The manual does provide some guidance on the use of superpipes to provide subsurface storage and reduce peak flows, however this is examined as lot level control only.
City of Vaughan Official Plan 2010 and Update	• The OP encourages the implementation of innovative stormwater management approaches where appropriate, however the application of non-conventional SWMFs is not identified within the Plan.
CVC/ TRCA Low Impact Development Stormwater Management Planning and Design Guide, 2010	• No reference to non-conventional end-of-pipe SWMFs within guideline.
TRCA Stormwater Management Criteria, August 2012	• Design criteria was not provided for non-conventional SWMFs, however it was noted that the TRCA encourages the implementation of innovative designs and green infrastructure, provided the proposed works also satisfy all applicable requirement and criteria set forth within the document.
City of Vaughan SWM Master Plan Class EA Study, 2014	• Non-conventional stormwater infrastructure was identified within the Class EA, however it was recommended for implementation at lot level rather than end-of-pipe SWMFs.
Active Together Master Plan (ATMP), 2018	• ATMP encourages the implementation of non-traditional parks and open spaces in areas of intensification, including strata parks developed on underground stormwater infrastructure, parking garages and roofs.
City of Vaughan Green Directions Vaughan, 2019	• Non-conventional SWMFs are not specifically identified within the document, however innovative approaches to enhancing stormwater management within the watershed are encouraged.
City of Vaughan Engineering Design Criteria & Standard Drawings, 2020	• The EDCSD does not provide design criteria or standard drawings for non-conventional SWMFs.

Existing Policy/ Procedure/ Guideline	Relevance to Implementation of Non-Conventional SWMFs
MECP Low Impact Development Stormwater Management Guidance Manual (Draft), January 2022	• Performance guidelines limited to lot level, at the source and conveyance controls, and excludes end-of-pipe facilities. • No reference to non-conventional SWMFs within guideline.
City of Vaughan Parkland Dedication Guideline, January 2022	• Guideline considers opportunities of parkland dedication for strata parks, where the City is provided ownership to parkland located over the top of underground structure or facility such as a stormwater management facility.
City of Vaughan MECP's CLI-ECA for Municipal Stormwater Management Systems, April 2022	• Identifies nineteen (19) non-conventional SWMFs (superpipes/ storage facilities) that have currently been authorized under the ECA. • Lists the stormwater management criteria under the CLI-ECA program.
Vaughan Sustainability Metrics Program, May 2022	• No opportunity to be awarded points for implementing non-conventional SWMFs.
City of Vaughan Parkland Dedication By-Law 168-2022, June 2022	• City will accept full (100%) credit towards satisfying the parkland dedication requirements for development or redevelopment of strata parks, and land encumbered by underground SWMFs, utility coordinators and other publicly owned infrastructure.
City of Vaughan Committee of the Whole (Working Session) Report, June 2022	• Defines the interim approach for approving non-conventional SWMFs. • Identifies the need to develop a formal policy and procedure for approval.

3 Stormwater Management Approval Process

Prior to implementation, applications for the installation of City assumed SWMFs must undergo a multi-stage review process, completed by the City and other relevant regulatory agencies, to ensure all stormwater related design criteria are achieved. The following sections provide a general overview of the current approach for the review and approval of conventional and non-conventional SWMFs within the City of Vaughan. In addition, data gaps identified during the review of the current interim approval process for non-conventional SWMFs have been identified.

3.1 City of Vaughan Approach for Conventional SWMF Approval

The City's process for approval of conventional SWMFs requires a developer to follow a multi-stage application process where several design submissions are reviewed by various internal departments within the City prior to being granted approval to proceed. Upon commencement of the project, the developer must initially determine and receive approval of the Block limits that the facility will occupy. This process is typically completed through a 'Draft Plan of Subdivision' process, where conditions for the approval of these facilities is listed. Subsequent to the Draft Plan of Subdivision is the Plan of Subdivision, where the detailed design of these SWMFs is completed and approved.

A detailed design submission of the SWMF is to follow, where the City relies on the criteria outlined in the City of Vaughan Engineering Design Criteria & Standard Drawings (2020), the MECP

Stormwater Management Planning & Design Manual (2003) and the TRCA Stormwater Management Criteria (2012) for review and approval of proposed conventional SWMF. Both the City and TRCA criteria reference recommendations detailed in the MECP SWMP Manual, including the application of the following criteria:

- At a minimum, pre-development peak flows are to be maintained to adhere to water quantity objectives. Watershed specific targets have been established by the TRCA and are to be adhered to when discharge to TRCA jurisdiction is proposed.
- A minimum 80% total suspended solids (TSS) is to be removed from 90% of the site average runoff to achieve water quality objectives.
- A minimum 5mm across the site area is to be retained on-site for water balance and erosion control criteria. Depending on the results of an erosion assessment, extended detention of the 25mm event for a 48-hour period may also be required.

Further to the above, the City and TRCA have outlined various criteria and provides guidance on the design, construction, and maintenance of the facility outlets, spillways, safety measures, and plantings. Additional design guidance including, but not limited to, the sizing of SWM pond forebays, extended detention, active storage, and sediment drying area is provided in the MECP SWMP Manual. In summary, conventional SWMF are to demonstrate:

- Satisfactory quantity, quality, water balance, and erosion control (if required).
- Acceptable lengths, depths, side slopes, area ratios, and volumes of the facility forebay, permanent pool, and active storage, if applicable.
- Satisfactory inlet/outlet minimize size, slope, and elevations.
- Adequate spillway and emergency overflow design and stone protection.
- Accessible maintenance route alignment, slopes, widths, and turn-arounds (if required).
- Acceptable safety fencing, signs, buffers, and vegetation/plantings.

A Stormwater Management Report, sealed by a Professional Engineer licenced in Ontario, that demonstrates satisfactory results of all applicable conditions and criteria, must be submitted to the City for review in order to receive final approval. In addition to the City and TRCA, the MECP must also be in receipt of this final approved SWM Report as part of the Consolidated Linear Infrastructure Environmental Compliance Approval (CLI-ECA) process. An application detailing the proposed SWMF, including site location, watershed/receiving system, drainage area size, ownership, land use, type of facility, operations/maintenance, and specific details on the facility (ie. treatment level, volume retention, storm event, treatment train, sewers/outfalls) is to be submitted to the MECP alongside the processing fee and final SWM Report for final review and approval before the construction phase of the project can commence. Additional considerations, including defining operation and maintenance requirements, costs and warranty periods must also be agreed upon between the owner and City prior to being granted final approval.

3.2 City of Vaughan Interim Approach for Non-Conventional SWMF Approval

As previously noted, an interim approach for approving non-conventional SWMFs was adopted by City Council in June 2022 in response to increased pressure by developers to approve innovation stormwater solutions for greenfield and infill/intensification developments within the City of Vaughan. The interim approach was modelled using similar policy framework to that implemented by the City of Markham, which required financial compensation to be paid by the developer to cover the cost differential between operation, maintenance, rehabilitation and replacement a non-conventional SWMF vs. conventional SWMF over a 50-year lifespan. In addition to the financial implications, the

approach provides details on design limitations and considerations that must be addressed by the developer prior to the City considering approval of non-conventional SWMFs.

Key features of the interim approach for accepting non-conventional SWMFS are as follows:

- The developer must provide reasons for the non-compliance of the City's OP policies for stormwater infrastructure;
- A recommendation report shall be prepared by a qualified engineer identifying and documenting the benefits of the proposed non-conventional SWMFs, which shall be submitted to the City for review and approval prior to development application. If City staff disagree with the provided rationale, a peer review consultant will be retained to provide their professional opinion, with costs of the review paid by the developer;
- Non-conventional SWMFs will not be supported for greenfield developments unless a compelling argument outlining the benefits is demonstrated to the City and the City's peer reviewer, if required;
- Consideration of non-conventional SWMFs may be considered for specific growth areas and intensifications/infill development based on land constraints and the proposed density;
- Prior to final approval, the owner shall provide a one-time cost contribution in present value for non-conventional SWMF to compensate for any increase in cost when compared to conventional SWMFs, based on operation, maintenance, rehabilitation and replacement costs over a 50 year lifecycle;
- Non-conventional SWMFs proposed under road right of ways should be avoided;
- For park development on top of non-conventional SWMFs, the following should be considered:
    - Park program flexibility and design restrictions;
    - Technical details (soil depths, tree canopy, etc.);
    - Disruption due to operation and maintenance;
    - Long term life cycle costs on park replacement;
    - Capital costs due to structural constraints; and,
    - Requirements for developer to build the park to ensure warranties are not voided.
- Provisions for parkland credits for dual-use parks/ underground SWMFs was considered through the Parkland Dedication By-law update, as described in **Section 2.4** above.

The overall approval process for non-conventional SWMFs follows the same general steps as conventional facilities, as outlined above in **Section 3.1**. However, the acceptance of a non-conventional SWMFs application is considered by the City on a case-by-case basis, and must include supporting documentation justifying the need to implement a non-conventional SWMF in addition to defining how water quality, quantity, erosion control and water balance targets will be achieved. These design targets are the same for both conventional and non-conventional SWMFs and are clearly defined within the TRCA, MECP and City guidelines. As noted above, these guidelines provide additional design recommendations specific to conventional SWMFs, such as spillway sizing and outlet pipe requirements for traditional stormwater management ponds, however no technical recommendations are provided explicitly for the design of non-conventional SWMFs. As a result, the preparation of the design of non-conventional SWMFs is reliant on the experience of the designing engineer, with additional support provided by the suppliers and manufacturers of these non-conventional SWMF products.

Similarly, the review and approval of the technical design of the non-conventional SWMF is also reliant on the knowledge and experience of the City's Engineering Department and all other supporting departments, as standardized technical requirements have yet to be defined within the interim approval approach or regulatory policies and guidelines.

3.3 Data Gaps in Interim Approval Approach of Non-Conventional SWMFs

As previously noted, the approval of a non-conventional SWMFs is currently completed on a case-by-case basis, which guarantees that the SWMF can effectively meet the stormwater management needs of the site while also securing financial contributions to the City to cover the additional ownership costs associated with the non-conventional SWMF. This current approach does not take into consideration numerous other factors including the social, economic and environmental impacts of implementing non-conventional SWMFs, nor assess the benefits or drawbacks this infrastructure could have on future communities.

The following data gaps have been identified during the review of the current interim approach, which have been divided into the following six (6) key categories:

- Engineering Design;
- Development Planning and Policy;
- Urban Design;
- Parks Planning;
- Active Outdoor Recreation;
- Lifecycle implications; and,
- Operation, Maintenance, Rehabilitation and Replacement.

By identifying these data gaps in the initial stages of the project, Resilient can ensure that this missing information is addressed during the development of the formal policy, procedure, and design criteria for non-conventional SWMFs approval. It is anticipated that throughout the consultation process additional data gaps within the interim approach will be identified by internal and external stakeholders. These recommendations will be documented accordingly and incorporated into the formal documents where appropriate.

Table 2. Key Data Gaps in the Current Interim Approach of Non-Conventional SWMF Approval

Engineering Design
• **Design specific criteria for non-conventional SWMFs is needed**. The design of conventional SWMFs is highly reliant on engineering design criteria outlined in the MECP Stormwater Management Planning and Design Manual (2003) and TRCA Stormwater Management Criteria (2012), which are referenced throughout many of the policies and guidelines reviewed in **Section 2** of this report. This engineering criteria is limited to conventional SWMFs and does not provide any criteria related to specific design elements of non-conventional SWMFs. • **Need for specification of acceptable technology**. At this time, the current approach for approval of non-conventional SWMFs does not provide any direction as to which types of non-conventional SWMFs may be accepted within the City of Vaughan. Numerous innovative stormwater management technologies are available on today's market, including plastic arch chambers, superpipes and concrete tanks. Each of these non-conventional SWMFs are made of different materials that adhere to various Canadian standards, require different levels for maintenance, and have varying operational lifespans. • **Direction on treatment train expectations.** Similar to conventional stormwater management approaches, non-conventional approaches are still required to achieve water quality, quantity, erosion control and water balance standards specific to their proposed site location. Achieving these standards through the implementation of the non-conventional SWMF alone may not be feasible, and lot level or conveyance controls and additional water quality measures may be required to meet these requirements. The formal approach should confirm the minimum requirements that are to be provided by the non-conventional SWMF as a standalone facility, and what requirements can be achieve elsewhere though the implementation of a treatment train approach.

Development Planning and Policy
• **Inclusion of Parkland Dedication By-Law 168-2022**. Following adoption of the interim approach for approval of non-conventional SWMFs in early June 2022, the Parkland Dedication By-Law was passed by Council on June 28th, 2022. The By-Law states that the City may accept full (100%) credit towards satisfying the parkland dedication requirements for development or redevelopment of strata parks, and land encumbered by underground SWMFs, utility coordinators and other publicly owned infrastructure, as long as the additional approval requirements as per Section 3 (3) of the By-Law are achieved. • **Good Planning Sense.** The implementation of non-conventional SWMFs may provide many benefits particularly when reviewing land value, however the social, community and mental impacts of not providing a conventional SWM pond, which is often seen as amenity space to residents, needs to be reviewed.
Urban Design
• **Urban Design Factor Integration.** The interim approach does not specify how to address potential impacts (both positive and negative) to urban design form of parklands above non-conventional SWMFs. Examples of urban design aspects to be considered ensuring that the placement of access points and maintenance routes do not conflict with critical public realm components of parks such as gathering places or recreational spaces.
Parks Planning
• **Need for specification of acceptable recreational facilities above facility.** The current approach for approval of non-conventional SWMFs identifies a list of considerations for park development to be located on top of non-conventional SWMFs, however specific expectations for what will be accepted above these facilities is not provided. A list of suitable recreational facilities that will be accepted above the facility, such as sports fields, plazas and rinks, and what will not be accepted will provide guidance in selection of the overall non-conventional SWMF design, specifically in relation to facility configuration, cover depth, soil types and loading requirements. • **Definition of planting expectations above facility**. The City of Vaughan is committed to promoting the planting of trees for enhancement of City parks. The implementation of non-conventional SWMFs below parkland can significantly impact where trees can be planted within the site, largely due to the impact of the plant roots on the structural integrity of the underground facility and the depth of soil cover above the facility. The existing approach does not define minimum planting requirements for within these parks.
Active Outdoor Recreation
• **Identification of park programming goals needed.** Early identification of the City's intentions for parkland located above these facilities, whether it be for passive or active programming, will have a considerable impact on the design and configuration of the proposed non-conventional SWMFs.
Lifecycle Implications
• **Development of standardized cost for operation, maintenance, repair, and replacement needed**. As non-conventional SWMFs are a relatively new and evolving concept for local municipalities, there is limited understanding of the cost associated with operation, maintenance, repair, and replacement of these facilities. One-time cost contributions collected from developers have largely been estimated at this time, with the hope that these financial contributions are sufficient to cover the additional costs associated with the implementation on non-conventional SWMF over their lifetime. As a result, the City has faced significant financial risks in approving these facilities.
Operation, Maintenance, Rehabilitation and Replacement
• **Development of Standard Operating Procedures (SOPs) required.** The long term operation, maintenance, rehabilitation and replacement needs for non-conventional SWMFs is not defined in the City's current SOPs. A new SOP will be required, which will include, but not be limited to, inspection programs, including frequency of inspection, the methods or test employed to detect when maintenance is required, health and safety procedures and all additional regulatory requirements identified by the MECP.

4 Review of Current Industry Practices

To develop a better understanding of the industry standard, six (6) municipalities within the GTA and surrounding area were contacted to determine if any policies, procedures, or design criteria has been applied within their municipality to address non-conventional SWMFs acceptance and implementation. These municipalities were selected based on their sizes and current development pressures being similar to Vaughan's. At the time of finalizing this report, responses were received from the following municipalities:

- City of Markham;
- City of Mississauga;
- City of Hamilton;
- City of Kitchener; and,
- City of Burlington.

Based on feedback received from these municipalities, no other municipality within the GTA and surrounding have created a formal approval policy or standards for the acceptance of non-conventional SWMFs or provided requirements for financial contributions from developers to operate these facilities on City lands. As previously noted, the exception to this is the City of Markham, who has implemented a policy to collect financial contributions for the cost differential between conventional and non-conventional SWMFs, should the developer propose implementation of non-conventional SWMFs. All correspondence with municipalities contacted as a part of this background review is provided in **Appendix B**.

4.1.1 City of Markham, Ontario

The City of Markham has been identified as the only municipality in the GTA to have prepared a document or policy addressing non-conventional stormwater infrastructure.

In 2019, the City developed an Alternative Infrastructure Policy ('AIP') which provides framework for the approval of alternative forms of infrastructure and details how additional costs incurred by the City over the lifespan of the infrastructure would be recovered. The policy is applied when a developer seeks to build alternative infrastructure, such as non-conventional SWMFs, that may result in a higher total cost of ownership to the City when compared to more conventional infrastructure, such as SWM ponds. The City requires payment by the developer of the cost differential between conventional and the alternative infrastructure based on two (2) lifecycles to a maximum of 50 years. Approval of the alternative infrastructure and determination of the required payment is completed on a case-by-case basis, and the policy has currently been applied to two (2) underground SWMFs located within the Village of Fairtree Subdivision. Lifecycle cost estimates for conventional and alternative infrastructure are currently being refined by the City of Markham to ensure all important components of future maintenance, operation and replacement are taken into consideration when determining the fee to be paid by the developer.

The latest discussions regarding the implementation of non-conventional SWMFs within the City of Markham occurred during the Development Services Committee Meeting on June 13th, 2022. A overview on SWMFs owned by the City was presented by the City's Director of Engineering, with specific focus on underground ('U/G') stormwater tanks and the opportunities and constraints associated with their implementation. The presentation touched on the City's current AIP, as well as discussed how parkland credit designation for parks located above these U/G tanks is currently being negotiated on a case-by-case basis. The following recommendations were presented and moved by the Committee:

- That proposals for U/G tanks be reviewed on a case-by-case basis by Engineering and Planning Departments, in consultation with Environmental Services Department, to ensure that the proposed location is appropriate, and the proposed type of U/G tank meets the City's specifications and criteria;
- That the Engineering Department, in consultation with Planning and Environmental Services Department, procures the services of a professional engineering consultant to assist in the development of appropriate criteria of acceptance for the considerations of U/G tanks, along with the acceptable uses above the facilities, along with the necessary specifications on U/G tank facilities.
- That the developers proposing to install U/G tanks in lieu of open stormwater ponds must provide the City with a financial contribution to offset the additional future costs to maintain and operate the U/G tanks and staff be authorized to negotiate the financial contributions from the developers.
- That the Planning Department be authorized to determine the applicability of parkland credits for proposed uses on top of U/G tanks and negotiate the appropriate parkland credit for proposed parks deemed suitable to be located on top of U/G tanks.

At this time, the City of Markham has yet to retain the services of a professional engineering consultant to assist in the development of criteria, standards and specifications for acceptance of U/G tanks, however this is anticipated to be initiated in the near future.

4.1.2 City of Mississauga, Ontario

Unlike many other municipalities within the GTA, the nature of development within the City of Mississauga is largely limited to intensification and redevelopment, as limited greenfield sites remain within the jurisdiction. As a result, Mississauga has received limited pressure from developers to implement non-conventional SWMFs on public lands and has not identified the need to adopt non-conventional stormwater management policies, procedures, or standards at this time.

Non-conventional SWMFs, including underground arch chambers and concrete tanks, have been implemented internally by Mississauga below existing public park space. These projects however have primarily been installed as flood mitigation retrofits, with the financial burdens of operation, maintenance and repair costs taken into consideration prior to implementation by the City.

4.1.3 City of Hamilton, Ontario

At the present time, the City of Hamilton is currently in the process of developing Green Standards and Guidelines related to development on private properties, with the intention to development similar guidelines for public infrastructure in the future.

Similar to many other municipalities, the implementation of non-conventional SWMFs on lands that are to be assumed by the City are completed on a case-by-case basis. At this time, proposed non-conventional SWMFs for public infrastructure is very uncommon, with the City largely only receiving development applications for non-conventional SWMFs on private land.

The City is also in the process of commencing an urbanization project that will require the implementation of municipally owned non-conventional SWMFs, however this project is still in its infancy, and the design of these non-conventional SWMFs have yet to be completed.

4.1.4 City of Kitchener, Ontario

The City of Kitchener relies upon the following set of documents when making decisions in relation to the approval of stormwater management infrastructure:

- Integrated Stormwater Management Master Plan and Policy (2016), which provides details on design criteria, targets, and fees;
- CLI-ECA, which defines MECP design criteria and maintenance requirements applied to the whole City of Kitchener stormwater network;
- City of Kitchener Development Manual (2021), which provides futher details on design criteria for end-of-pipe facilities. End-of-life facilities are identified as wetlands, ponds and infiltration facilities as per the Manual;
- Operation and Maintenance SOPs and best management practices, when available; and,
- Stormwater Asset Management Plan (2022), which provides guidance on asset maintenance, rehabilitation and replacement needs.

The City of Kitchener does not have a policy specifically related to the implementation of non-conventional SWMFs, and instead takes a non-prescriptive approach to reviewing these facilities, ensuring that objectives of the above documents are achieved by the proposed facility.

4.1.5 City of Burlington, Ontario

The City of Burlington Stormwater Management Design Guideline, prepared in 2020, is used for the review and approval of all stormwater management systems and infrastructure proposed within the City of Burlington. The Guidelines provide detail on the design process, submission requirements, modelling and overall design criteria for conveyance and stormwater management infrastructure. As defined in the Guidelines, end-of-pipe SWMFs consist of systems with open ponding areas used to provide quantity, erosion, and quality controls to mitigate development impacts, and may refer to dry ponds, wet ponds, wetlands or hybrids. The Guideline does not provide any criteria or requirements related to the implementation of non-conventional SWMFs.

5 Review of Non-Conventional SWMFs

The use of conventional SWMFs, such as dry or wet ponds, have been used for many decades as a means to adhere to stormwater management criteria set forth by provincial, regional and local regulatory authorities. The implementation of these conventional facilities, when compared to alternative forms of stormwater management, were preferred by developers as construction costs were significantly less than alternative options, such as underground facilities. As the price of developable land continues to elevate, the use of these conventional facilities is becoming less desirable as a large capital investment is needed for the land. The City currently owns approximately 147 conventional SWMFs, with another 16 non-conventional SWMFs in various phases (ie. assumed, approved, under review), which include underground storage tanks and superpipes to provide required stormwater management controls.

There are many potential advantages to implementing a non-conventional SWMF, including but not limited to:

- Provides a dual-purpose to the land (i.e. parkland above the facility);
- Requires a smaller at-surface footprint;
- Eliminates at-surface water quality concerns such as standing water and E.Coli contamination from wildlife;
- Provides both passive and active programming of the space above the facility;
- Lowers water temperature of discharge; and,

- Improves safety by eliminating the potential of drowning and/or falls through ice.

Non-conventional facilities are becoming increasingly popular, especially in the GTA, as available land is limited resulting in highly constrained sites. These facilities may be ideal for land development projects where additional land is not available for a conventional system, and in park settings where the land can be re-purposed above the facility.

Although a long list of advantages are noted for non-conventional SWMFs, there are some significant potential disadvantages including a higher overall cost for installation, maintenance, operation, repair and replacement when compared to conventional SWMFs. Non-conventional SWMFs are typically buried underground, and are reliant on engineered products or structures with design lives of 50 to 100 years to support the ground above the facility. In the case of open excavated ponds, while there may be risk of erosion of slopes or failure of outlet structures, there is no risk of collapsing ground as the facility is not buried and notable deficiencies with the infrastructure are more readily observable.

Non-conventional SWMFs typically utilize a pre-treatment system to remove a majority of suspended solids in stormwater before entry to the main facility. Pre-treatment systems are designed to be frequently maintained through relatively simple methods such as flushing and vacuuming using equipment typically owned or contracted by the asset owner. However, for many non-conventional SWMFs, if pre-treatment is not maintained, sediment will begin entering and accumulating within the main facility, resulting in loss of storage volume and reducing effectiveness of the SWMF. Removal of sediment from the main facility may be much more difficult and may require excavation and replacement of engineered products, resulting in higher costs and disruptions to facilities.

The review of several types of facilities has been completed to highlight the various advantages and disadvantages for each facility, including capital and lifecycle costs, operation/maintenance requirements, and all other identified limitations and considerations. The objective of this review is to provide the required supporting documentation for use in preparing a list of non-conventional SWMFs that will be accepted for implementation within the City of Vaughan. The detailed review of various types of non-conventional SWMFs is included in the following sections, with a summary presented in table format included in **Appendix C**.

5.1 "Milk-Crate" System

The "milk-crate" system gets it name from its appearance – a box-like modular system with thin walls that include openings to allow for the passage of water. These systems are made of high-density polyethylene ('HDPE') and are available in a variety of standard heights. The product can be stacked to achieve a required height or increase storage volume while maintaining a limited footprint. The forms have been designed for standard loading applications including loads from parking lots/industrial areas, however adequate coverage over the facility is required. Infiltration can be promoted through the system through the installation of open-bottom facilities or restricted through the use of an impermeable liner.

A variety of suppliers for this type of system exist and include:

- Layfield Group: *Brentwood StormTank Module*
- Atlantis: *Matrix Tank*
- ACO: *Stormbrixx*
- StormCon: *Greenstorm Geocellular Module*

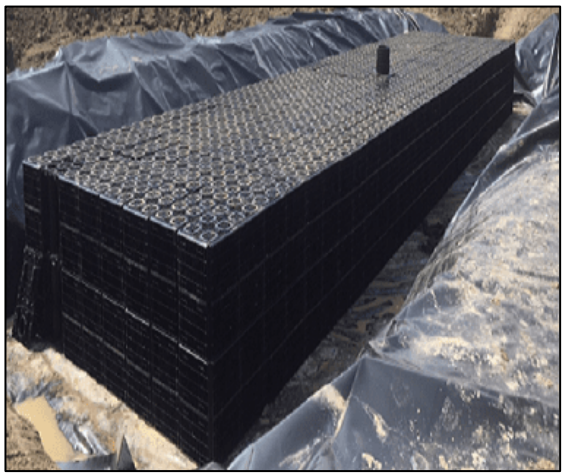


Figure 1: Example "Milk-crate" system, Source: ACO

The main advantage of the "milk-crate" system is the high void ratio (over 95%) when compared to its arch chamber competitors. The square shape of each modular unit allows for the system to maximize internal storage space without losing potential storage opportunities to exterior stone or perimeter material. Another advantage of these products is the quick and easy assembly of the facility. As the systems are made of plastic materials, the system can be snapped into place by hand without the need for large equipment. In addition, these products come disassembled and therefore packaging and shipping is improved over its competitors.

The main disadvantage of the "milk-crate" system is that it forms a closed facility in the sense that entry is not a possibility without excavation and local disassembly of the system. Further to this, the system has minimal opportunity for quality treatment and is therefore reliant on an external treatment device. This increases the risk of sediment-laden water entering the facility, increasing the maintenance frequency of the system and quality treatment system. Maintenance of these facilities is paramount to their success and therefore frequent inspection via camera and subsequent maintenance is recommended to minimize the risk of having to excavate and replace the system.

During the design of "milk-crate" systems, groundwater elevation needs to be taken into consideration to ensure groundwater seepage into the facility is not anticipated and to confirm if an impermeable liner is required. If infiltration is required by the system, verification that there is adequate separation between the bottom of the system and the groundwater table is required. This consideration is not typically required for the design and implementation of concrete-based facilities, as they are often designed to be watertight systems. Lastly, these types of facilities are less common in the industry and therefore contractor familiarly with the product may be limited, and prices elevated as a result when compared to other arch style SWMF products.

A key limitation to the implementation of "milk-crate" systems is restrictions imposed by burial depth and the standard height sizes. The pre-made structures are manufactured to specific heights that may not work within a highly constrained site. Another limitation to this system is that the facility cannot be entered for inspection and maintenance. While pathways in the facility are provided for inspection using CCTV equipment, manual entry is not possible. As a result, excavation of the system is required to address any repairs or extensive maintenance required for the system.

Maintenance of "milk-crate" systems include semi-annual inspection for the first 5-years and additional inspection after every large storm event to ensure the facility is operating as designed. After 5-years, inspection can be reduced to an annual basis where visual inspection of the facility and sediment accumulation is completed through the inspection ports. A VacTruck and high-pressure flusher nozzle is required to perform maintenance on the facility once sediment accumulation reaches the maximum acceptable depth specified by the supplier. It is noted that confined space entry is not required for inspection or maintenance of these facility types.

In regard to costs of these facility, the "milk-crate" system is more expensive than their plastic arch shape competitors, as these facilities are usually selected for the stacking capability which ultimately require deeper excavations. However, stone quantities required for installation are less than arch

chamber systems. The estimated installation cost for these systems is approximately $500/m^3 of storage.

With proper maintenance, these facilities are estimated to have 50-year lifespan before replacement is required. This assumes that inspection of the facility is performed on an annual basis, and inlets/outlets are regularly cleared of any debris. As confined space entry of these facilities is not possible, maintenance costs are reduced when compared to the concrete systems that allow entry for major rehabilitation assessment. The results of the lifecycle assessment indicate that the "milk-crate" system has the third lowest capital cost compared to over non-conventional SWMF systems. Maintenance costs of these facilities are the lowest, however life-expectancy is half that of the assessed concrete systems and therefore replacement of these structures after 50-years has been included in the assessment. Refer to **Appendix D** for the lifecycle assessment for each non-conventional SWMF.

5.2 Plastic Arch Chambers

The plastic (or polymeric) arch chamber system is widely used and accepted in industry in the GTA and south-western Ontario. These systems are made of HDPE and formed in arch shapes at various standard heights and lengths. The system consists of end caps, clear stone, manifolds, connecting piping, and modular chambers that easily snap together on-site. Plastic arch chamber systems can be designed to be water-tight through the use of an impermeable liner, or provide infiltration capabilities by designing an open-bottom facility. The plastic arch chamber system can also provide water quality treatment by incorporating an "isolator row" at the beginning of the system, which consists of a row of chambers that has been wrapped entirely in geotextile. The inlet connection in the "isolator row" is set at a lower elevation than the rest of the system, encouraging the first flush that is heavy in sediment to enter this row rather than dispersing throughout the system. There are various suppliers of the plastic arch chamber system, including but not limited to:

Figure 2: Example of Arch Chamber System, Source: ADS

- ADS: *Stormtech Chambers*
- Terrafix: *Triton System*
- Cultec: *Recharger Unit*
- Soleno: *StormChamber*

The main advantage of the plastic arch chamber system is their versatility and the industry wide familiarity with the product. As previously mentioned, the majority of underground SWMFs currently approved by various municipalities are plastic arch chamber systems. Therefore, several designers, engineers, contractors, and regulatory agencies have experience with the product, which leads to a higher chance of successful implementation. Canadian Standards Association (CSA) has a series of standards B184 "Polymeric subsurface stormwater management structures". These documents provides guidance and surety for designers and reviewers as it includes standardized requirements for:

- Materials and manufacturing;

- Design and structural integrity;
- Durability and longevity; and,
- Storage capacities and tolerances.

It is noted that the current editions of CSA B184 series covers arch-shaped stormwater management structures only, and other types of structures will be considered for future editions.

From a technical perspective, the plastic arch chamber systems have been identified to achieve water quantity, quality, and water balance requirements within the facility, removing the need for lot level and conveyance controls. The "isolator row" implemented within the facility has recently been ETV certified to achieve the minimum 80% TSS removal therefore removing the need for an external treatment system in many cases.

A large component to the function of these facilities is the clear stone placed at the system's base, between the chambers, and as cover material above the chambers. This clear stone provides a level base to install the product on, promotes infiltration between the system, and acts as structural cover over the system. The use of clear stone can be beneficial to the overall system, as it provides a void ratio of 0.40 allowing for additional storage opportunities. The placement of this clear stone is often completed using a stone slinger, therefore space for equipment setup should be considered prior to selection of this SWMF type. The import of large quantities of stone results in significant truck traffic and stockpiling requirements during construction of larger facilities.

Other disadvantages to plastic arch chamber systems are the need to confirm groundwater elevations, as high groundwater elevations will require the implementation of an impermeable liner below the system. This consideration is not typically required for the concrete facility competitors, which can be installed as watertight systems. In addition, maintenance of these arch chambers can be difficult given the shape of the infrastructure, particularly with the smaller units where manual entry is not feasible. If the facility were to become damaged and settlement from the surface is observed, a full excavation and replacement of the damage section is required, as minor rehabilitation is not an option for these facilities.

The key limitation to the plastic arch chamber system is the required burial depth to accommodate the top layer of stone and minimum cover requirements over the structures. This limitation plays a factor in the design process, particularly on sites with shallow servicing connections. While various heights of the structures are available, the heights are pre-determined and therefore changing to a smaller unit may be required when height is a constraint. Some arch chamber systems allow for stacking of more than one layer of storage units, however stacking of units may increase the potential of structural failure and must be considered carefully.

Maintenance of these facilities include semi-annual inspection for the first year of operation and after every large storm event. Annual visual inspection of the facility through the inspection ports is to be completed and sediment accumulation depth measured to confirm if maintenance on the facility is required. As sediment accumulation should be limited to the "isolator row" in a properly functioning system, maintenance should be limited to the use of a VacTruck and high-pressure flusher nozzle within this row only. Confined space entry is not required to complete maintenance on the facility; however, entry is possible in the larger systems if needed.

The estimated initial capital cost to install a plastic arch chamber system is approximately $\$250/m^3$ of provided storage. With proper maintenance, these facilities are estimated to last 50-years before replacement is required. This assumes that inspection of the facility is performed on an annual basis, and inlets/outlets are cleared of any debris to ensure proper function. As confined space entry of these facilities is not possible, maintenance costs are reduced when compared to the concrete

systems that allow entry for major rehabilitation assessment. The results of the lifecycle assessment indicate that plastic arch chamber systems have the second lowest capital costs and lifecycle cost. Maintenance costs of these facilities are the lowest, however life-expectancy is half of the concrete systems and therefore replacement of these structures after 50-years has been included in the assessment. Refer to **Appendix D** for the lifecycle assessment for each non-conventional facility.

5.3 Modular Concrete Chambers

Figure 3: Example Modular Concrete Chamber, StormTrap

Modular concrete chambers are another widely accepted non-conventional SWMF utilized in the GTA and southwestern Ontario. These systems are made of concrete box sections with partially open internal walls to allow for water movement throughout the system. The box sections are pre-cast within controlled facilities and can be formed at various standard heights and lengths. The systems can be designed to be water-tight or can promote infiltration by implementing a granular base below the facility. These facility types achieve high load bearing standards (HS-20) and are therefore attractive for roadway, parking lot, and industrial land uses. There are various suppliers of the modular concrete chamber systems, including but not limited to:

- Stormtrap: *SingleTrap, DoubleTrap*
- Contech: *Con/Span Detention System, Terre Arch*
- DECAST: *I-Storm*

The main advantage of these facilities is the high void ratio (over 95%) and high load bearing capacity, allowing for these structures to be placed at greater depths than the plastic alternatives on the market. Other advantages to modular concrete chambers include the versatility of these structure, as they can be installed below numerous services including parking structures, roadways, industrial parks, and residential buildings.

The main disadvantage of modular concrete chambers is the high upfront installation costs. These systems are typically more expensive than the plastic alternative, and have an increased cost of shipment, delivery, and staging. As this is a pre-cast structure, the pieces are large and bulky requiring numerous deliveries in comparison to an equivalent sized plastic system. The installation of modular concrete chamber system is also considerably more challenging than most other non-conventional types of facilities, as the chambers require heavy machinery to move and install. Available work space for operation and placement of this heavy machinery needs to be considered during the design phase of these projects.

Inspection of these facilities is required on an annual basis and after large storm events to confirm sediment accumulation depths and confirm the facility is operating as designed. Inspection can be completed through the facility inspection ports and confined space entry is typically not required for inspection, however entry is usually possible via standard maintenance hole openings. Once accumulation depths exceed the suppliers limit, maintenance on the facility is to be completed using a VacTruck and high-pressure flusher nozzle to break-up and remove debris. Maintenance frequency is estimated at 5-10 years for dry vault systems, and 3-5 years for wet vault systems.

The cost to implement modular concrete chamber systems can be quite high due to the pre-cast natural of the product and more strained shipment/delivery needs, with estimated costs in the range of \$1000/m^3 of installed storage. As noted above, there are many added benefits with this type of

facility, namely, the increased structural integrity of the system and its versatility. Assessment of site conditions, including expected loading for the land use and servicing depth constraints, is key when selecting if a modular concrete chamber system is required, or if a plastic unit would be better suited for the required application.

With proper maintenance, a modular concrete chamber system is estimated to have a 100-year lifespan before requiring replacement. This lifespan is conditional upon completion of the required inspection and maintenance, ensuring that inlets/outlets are cleared of debris and sediment is removed as needed. This lifecycle assessment also accounts for a confined spaced entry inspection and concrete repairs every 25-years to promote the longevity of these structures. The results of this assessment indicate that modular concrete chamber systems have the second highest capital cost investment, resulting to the second highest lifecycle cost. This can be attributed to the high cost of precast structures and relatively high maintenance costs. Refer to **Appendix D** for the lifecycle assessment for each non-conventional facility.

5.4 Superpipes

A superpipe facility includes the installation of large diameter pipes connected in sequence or series onsite to provide subsurface storage. These pipe systems are typically comprised of HDPE or corrugated steel pipe ('CSP') due to cost and weight considerations when compared to concrete pipes. Superpipe systems are limited in functionality, as they can only provide quantity control within the end-of-pipe facility, and do not provide infiltration or quality control. To provide quantity control, a small diameter conveyance pipe is located at the outlet of the superpipe system which acts as an orifice control reducing peak flows and retaining water within the system. Marginal water quality benefits may be experienced within a superpipe facility, as the system ultimately provides a flat space where coarser material can settle. However, credit towards 80% TSS removal through the implementation of a superpipe system is not recognized in the industry. External quality control devices are required upstream of these facilities to minimize maintenance requirements and meet SWM design criteria. There are several suppliers of storm sewers, but those particular to stormwater detention include, but are not limited to:

- Soleno: *Solfo* and *Wheolite Detention Systems*
- ADS: *N-12 Pipe Retention System*
- Contech: *CMP* and *Duromaxx Systems*

Figure 4: Example of Superpipe System, Source: Contech

Like plastic arch chamber systems, one of the many advantages of superpipe systems is their familiarity in industry and design simplicity. Installation of pipes and sewers is a common practice for many contractors and is considered the easiest of all assessed non-conventional SWMFs to implement.

The main disadvantage of a superpipe facility is its lack of versatility, as the system only provides peak flow reduction and does not achieve water quality or water balance objectives. Therefore, a treatment train approach is required to adhere to current SWM standards. In addition, the cost of

material for this system is high when compared to some other non-conventional SWMFs reviewed during this assessment.

Key limitations of a superpipe system include the restriction on available pipe sizes. Although pipe diameters up to 3.0 metres are readily available from many suppliers, delivery of this size of pipe can become complicated as travel routes need to be considered. It is common practice to assume pipe diameters of 1.8 metres can easily pass under various bridge structures, with larger pipe diameters requiring confirmation to ensure adequate clearance is available before being delivered.

Other limitations of superpipe facilities include the minimum and maximum cover depths over the pipes. Further, these facilities are not well suited for large volume structures, and the price per cubic metre of storage is high and storage space opportunities are lost through the circular pipe shape when compared to a square shape product. Lastly, due to the size of these pipes, heavy equipment is needed on-site to install the product.

Maintenance of these facilities should be completed on an annual basis to monitor sediment accumulation and ensure adequate function of the outlet pipe. Visual inspection is completed through access manholes provided at the upstream and downstream ends of the facility. A VacTruck and high-pressure water nozzle is required to complete maintenance. Confined space entry is not required to complete routine inspection or maintenance of these facilities, although entry with appropriately certified personnel is possible in the large diameter systems, if required.

The price of a superpipe system is highly dependent on the material, size of the pipe and the depth at which it is installed. In general, larger diameter pipes have a higher price per linear metre of pipe, however the price per cubic metre of storage is lower than when compared to smaller diameter pipes. Further, shallower installed systems are cheaper as a result of less excavation than deeper systems. To compare with other non-conventional SWMF pricing, a typical cost of $\$2,000/m^3$ has been assumed, although this cost is recognized as being highly dependent on the characteristics of the subject site. An additional potential benefit of superpipes is that they can achieve a dual function of conveyance and storage in a single piece of infrastructure.

With proper maintenance, superpipe facilities are estimated to have a lifespan of 100-years before requiring replacement. This assumes that inspection of the facility is performed on an annual basis, and inlets/outlets are cleared regularly of any debris. Sediment and debris should be removed from the facility every 5-years, or when sediment accumulation depths are noted in excess during the inspections. Maintenance is completed using a VacTruck/Flusher to flush the system. The results of the lifecycle assessment indicate that a superpipe system has the highest capital and lifecycle costs. Refer to **Appendix D** for the lifecycle assessment for each non-conventional facility.

5.5 Cast-in-place Concrete Facility

The implementation of cast-in-place concrete facilities utilize traditional cast-in-place techniques (using manually assembled formwork removed after concrete curing) to construct an underground stormwater tank. These facilities do not use sacrificial form systems to construct the facility, but rather use standard concrete forms to create the tank. The system is often designed to be watertight and requires the installation of

Figure 5: Example cast-in-place concrete facility

a concrete base slab, therefore removing the ability for the SWMF to promote infiltration. A baffle wall can be incorporated in the system design to provide some pre-treatment for water entering the facility. This pre-treatment chamber can promote the settling of sediment and debris; however, quality control objectives can not be achieved within the use of this pre-treatment chamber alone, and additional measures such as an OGS unit is required to meet water quality targets. With the exception of columns required for structural support, the interior of a cast-in-place concrete tank is largely open space that can provide significant storage opportunities and has a very high void ratio (over 95%). These facilities can also be designed with very high load bearing capacity making it ideal for areas with high vehicular traffic (i.e. parking lots, industrial areas, and roadways). These facilities do not have specific suppliers, but rather require a specialized concrete contractor with experience to form, place reinforcement and pour the required concrete.

The main advantage of a standard cast-in-place concrete facility is that they are highly customizable and are not constrained by any pre-made supplier products.

The main disadvantage of these cast-in-place facilities is the high costs associated with construction and increased construction time to allow for concrete curing. These SWMFs require a large quantity of concrete and reinforcement to construct, therefore cost of installation is highly dependent on the availability and price of steel and concrete at the time of construction. A significant amount of labour is required to construct forms and reinforcement, particularly for roof slabs of the facility. The implementation of this type of facility also requires specialized concrete contractors, whereas other non-conventional facilities (such as arch chambers or milk-crate systems) are constructed by civil contractors responsible for site servicing. The success of these facilities is highly dependent on the Contractor's ability to construct a high-quality concrete structure.

Another disadvantage to cast-in-place concrete facilities is construction complications associated with installation of these facilities during the winter months. Considerations for time delays, protection/insultation, and heating of the concrete should be considered when developing an accurate budget and schedule for the project. The GTA experiences temperatures below -5°C and combined with snow and mixed precipitation for 3-4 months of the year, therefore restricting the window for suitable weather conditions for concrete construction. To reduce the impact of these conditions on construction, cast-in-place concrete facilities should be planned to commence in the spring and finish before the winter.

Maintenance of these facilities should be completed on an annual basis to monitor sediment accumulation and ensure adequate function of the outlet pipe. Visual inspection is completed through the access manholes provided at the upstream and downstream ends of the facility. A VacTruck and high-pressure flusher nozzle is required to complete maintenance. Confined space entry is not required to complete routine inspection or maintenance of these facilities, although entry with appropriately certified personnel is possible, if required. An upstream treatment unit can be incorporated into the storm network to provide pre-treatment of the incoming water and ultimately minimize sediment accumulation. Alternatively, a baffle wall can be included inside the tank to isolate any sediment and debris that enters the system and minimize the area requiring maintenance.

The estimated cost of a cast-in-place structure is approximately $\$1000/m^3$ of installed storage, which may fluctuate depending on the depth of the facility. There are added benefits with this type of facility, namely, the structural integrity allowing it to be placed at all reasonable depths with various amounts of loading. Assessment of the site conditions, including expected loading for the land use and servicing depth constraints, is key when selecting if the cast-in-place system is required, or if a plastic prefabricated option would be better suited for the site.

With proper maintenance, these facilities are estimated to last 100-years before needing replacement. On a bi-annual basis, entry into the facility is recommended to inspect and perform maintenance as required, including sediment removal from any baffle walls constructed to limit sediment entry to the main facility. Every 5-years, the facility may require debris and sediment removal from the main facility by use of a VacTruck and flushing equipment. This lifecycle assessment also accounts for a confined spaced entry inspection and concrete repairs every 25-years to promote the longevity of these structures. The results indicate that these facility types are similar to modular concrete chambers and have the second highest capital cost investment resulting in the second highest lifecycle cost. This can be attributed to the high cost of the custom formwork and relatively high maintenance costs. Refer to **Appendix D** for the lifecycle assessment for each non-conventional facility.

5.6 Modular Form Cast-in-place Concrete

The implementation of modular form cast-in-place concrete facilities have been growing in popularity in recent years given their structural integrity, long lifecycle, and ease of installation. These systems typically include a plastic forming system that is used to replace traditional concrete forming systems required for concrete structures. The forms are entirely sacrificial and do not provide any structural support to the facility. Similar to modular plastic chambers, the modular concrete forms are lightweight and easily snap together, allowing for installation to be completed by hand. These concrete facilities can be designed to be water-tight by using a concrete base slab and waterproofing material or can promote infiltration by using a granular base for the facility. Modular form cast-in-place concrete facilities achieve high load bearing standards (HS-20) making them attractive for construction below roadways, parking lots, and industrial land uses. These facilities provide a large void ratio (over 95%) with lost capacity limited only as a result of the plastic forms located within the tank (i.e. no stone involved). At this time, the leader in the industry responsible for supplying these sacrificial forms is CUPOLEX Engineering Solutions Inc.

The main advantage of the modular form cast-in-place facility is the forming system provides significant time saving opportunities when compared to traditional forming systems. Installation of the modular forms is significantly faster than traditional forms, and no time is spent removing the forms following completion of the concrete pour as the modular forms are to remain in place during operation of the facility. An additional advantage of modular form cast-in-place facilities is the height of the system can be customized within the design range specified by the supplier, providing an advantage over competitors that have products manufactured at pre-made standard heights. There is also a structural design advantage achieved through the use of the dome shaped forms, and frequent column spacing that is not feasible with traditional forming systems.

Figure 6: Example Modular Form Cast-in-place Concrete

The main disadvantage of the cast-in-place concrete system is the increased construction time for concrete curing and rebar placement when compared to the plastic and precast SWMFs reviewed during this assessment. In addition, modular form cast-in-place facilities are a relatively new

technology, therefore additional training time and effort is required for contractors who have limited experience in installing these facilities.

Similar to traditional cast-in-place facilities, cold weather concrete work is a key limiting factor to the implementation of modular form cast-in-place systems. Cold weather conditions typically experience in Ontario during the winter months are not ideal for constructing a cast-in-place concrete facility, and heating and insulating considerations must be taken into account to ensure the proper curing of the poured concrete.

Maintenance of these facilities is the same as the traditional cast-in-place systems. Inspection should be completed on an annual basis to monitor sediment accumulation and ensure adequate function of the facility. Visual inspection is completed through the access manholes/inlets provided throughout the facility. A VacTruck and high-pressure flusher nozzle is required to complete maintenance. Confined space entry is not required to complete routine inspection or maintenance of these facilities, although entry with appropriately certified personnel is possible, if required. An upstream treatment unit can be incorporated into the storm network to provide pre-treatment of the incoming water and ultimately minimize sediment accumulation. Alternatively, a baffle wall can be included inside the tank to isolate any sediment and debris that enters the system and minimize the area requiring maintenance.

The estimated cost to install a modular form cast-in-place system is approximately $\$250/m^3$ of storage. It is important to note that the system requires the use of concrete and therefore the price is subject is variability with the price of concrete. This price is the lowest of the evaluated options but can have potential delays depending on weather conditions. Although this system can be the least capital cost alternative, it is not recommended to be constructed during winter months so timing should be considered when deciding on the preferred system.

With proper maintenance, modular form cast-in-place facilities are estimated to last 100-years before requiring replacement. This lifecycle assessment also accounts for a confined spaced entry inspection and concrete repairs every 25-years to promote the longevity of these structures. The results indicated that these facility types have the lowest capital cost investment and ultimately the lowest life-cycle costs. This can be attributed to the long-life expectancy of these facilities, when compared to the plastic competitors that are expected to require replacement within 100-years. Refer to **Appendix D** for the lifecycle assessment for each non-conventional facility.

6 Next Steps

Upon completion of the Background Report, it is recommended that a stakeholder engagement session be arranged to review and discuss the results of the report, in addition to providing opportunity for relevant internal and external stakeholders to provide feedback regarding their concerns associated with the current interim approach to accepting non-conventional SWMFs. Resilient will then initiate the next deliverable of the project, which consists of the review and evaluation of the City's existing sixteen (16) non-conventional SWMFs. These facilities will be assessed based on their performance and will include the documentation of the pros and cons of each non-conventional SWMF.

The preparation of these review documents will ultimately support the development of Stage 2 of the project, which includes the development of a formal City of Vaughan Policy, Procedure, Engineering and Park Design Criteria and Standard Drawings.

APPENDIX A

Relevant Background Information

No.	Name of Document	Author	Date	Location
1	Stormwater Management Planning and Design Manual	MECP	March 2003	https://www.ontario.ca/document/stormwater-management-planning-and-design-manual/stormwater-management-plan-and-swmp-design
2	City of Vaughan Official Plan and Update	City of Vaughan	2010	https://www.vaughan.ca/projects/policy_planning_projects/official_planning_2010/Pages/default.aspx
3	Low Impact Development Stormwater Management Planning and Design Guide	TRCA/CVC	2010	https://files.cvc.ca/cvc/uploads/2014/04/LID-SWM-Guide-v1.0_2010_1_no-appendices.pdf
4	Stormwater Management Criteria	TRCA	August 2012	https://trca.ca/conservation/stormwater-management/understand/swm-criteria-2012/download
5	SWM Master Plan Class EA Study	City of Vaughan	2014	https://www.vaughan.ca/projects/planning_growth/SWMMP_EA/General%20Documents/Volume%201%20-%20SWM%20Master%20Plan%20Report_Final%20Sections%201%20-%207.pdf
6	Active Together Master Plan	City of Vaughan	2018	https://www.vaughan.ca/projects/community/active_together/General%20Documents/96-360%20Vaughan%20ATMP_Final_May%202018.pdf
7	Green Directions Vaughan	City of Vaughan	2019	https://www.vaughan.ca/cityhall/environmental_sustainability/GreenDirections/General%20Documents/2019Green%20Directions%20Vaughan%20FINAL.pdf
8	Engineering Design Criteria and Standard Drawings	City of Vaughan	December 2020	https://www.vaughan.ca/services/DesignCriteria/Pages/default.aspx
9	Low Impact Development Stormwater Management Guidance Manual (Draft)	MECP	March 28, 2022	https://municipalclassea.ca/files/7_DRAFT_MOECC_LID%20SWM%20Manual.pdf
10	Parkland Dedication Guideline	City of Vaughan	January 2022	https://www.vaughan.ca/cityhall/departments/pipd/pp/General%20Documents/Parkland%20Dedication%20Guideline_Jan_25_2022.pdf
11	MECP's CLI-ECA for a Municipal Stormwater Management System, ECA Number: 011-S701	City of Vaughan	April 2022	https://prod-environmental-registry.s3.amazonaws.com/2021-03/Guide%20to%20Applying%20-%20First%20Consolidated%20Linear%20Infrastructure%20ECA.pdf
12	Sustainability Metrics Program	City of Vaughan, Markham, Brampton and Richmond Hill	May 2022	https://www.vaughan.ca/cityhall/departments/dp/Pages/Sustainability-Metrics.aspx
13	Parkland Dedication By-Law 168-2022	City of Vaughan	June 2022	https://www.vaughan.ca/cityhall/departments/pipd/pp/General%20Documents/Draft%20Parkland%20Dedication%20By-law.pdf
14	Committee of the Whole (Working Session) Report on "City Approach on Non-Conventional Stormwater Infrastructure" and associated attachments	City of Vaughan	June 8, 2022	https://pub-vaughan.escribemeetings.com/filestream.ashx?DocumentId=108314

APPENDIX B

Correspondence with Municipalities

From: Muir, Robert
To: Mark Bassingthwaite
Cc: Saad Yousaf; Andy Lee; Rebecca Turbitt; Samantha Archibald
Subject: RE: Non-Conventional SWMF Industry Scan
Date: January 20, 2023 4:34:49 PM

Hi Mark,

We would be glad to support this and collaborate with our good neighbours in Vaughan.

We have a policy to recover the additional costs of alternative infrastructure (can include underground tanks), based on the differential over 50 years when compared to conventional/traditional servicing (e.g., with a wet pond) – this is called our Alternative Infrastructure Policy "AIP".

Council has directed us to evaluate costs on a case by case basis. This June 13, 2022 Development Services Committee meeting Item 9.1 had the latest discussion (see DSC minutes and presentation by my Development Services colleagues that our department (Environment Services) supported): meeting minutes: https://pub-markham.escribemeetings.com/Meeting.aspx?Id=d0d6f741-feb0-47f4-8c14-a744237ce3de&Agenda=PostMinutes&lang=English&Item=23&Tab=attachments, presentation: https://pub-markham.escribemeetings.com/filestream.ashx?DocumentId=55598

While we do a case by case evaluation I do see that having a process, and some accepted standardized cost items and unit costs, would be worthwhile. As we have reached out externally for support on costing we have found sometimes, for some items, that we may have robust costs internally to rely on (as we are maintaining/operating many assets already and some of our programs are long-standing).

We have applied the AIP for 2 plastic underground arch systems (Fairtree subdivision) – that was the first time we developed and applied this policy and admittedly the cost estimation was approximate. We are refining these costs and filling gaps for the more important components on the lifecycle costs though. Last spring we did a comparison of open flood control storage vs a RC underground tank and selected the open storage based on cost and other considerations (federal grant for natural infrastructure was at risk with a tank). Over the past ½ year we are repeating the assessment for 2 underground RC tanks now for North Markham developments. While there is no agreement with the developer on the AIP amount yet, we'd be glad to share what we've estimated as appropriate costs from our perspective.

We don't have a list of acceptable/unacceptable technologies, just general direction (June 2022 resolutions below) to ensure proposals are "appropriate". Resolution 5 is to develop criteria (performance standards, as opposed to approved products) which should support our review process. Markham will be seeking outside support to develop those criteria but that has not been initiated yet (lead will be Development Services I expect).

Recommendations (General)

4. Proposals for U/G tanks be reviewed on a case by case basis by Engineering and Planning Departments, in consultation with Environmental Services Department, to ensure that the proposed location is appropriate and the proposed type of U/G tank meets the City's specifications and criteria;
5. Engineering Department, in consultation with Planning and Environmental Services Departments, procures the services of a professional engineering consultant to assist in the development of appropriate criteria of acceptance for the consideration of U/G tanks, along with the acceptable uses above the facilities, along with the necessary specifications on U/G tank facilities;

20

I hope that helps share where we are and where we are going. Let me know if there are any questions and how we may fit in to your worthwhile endeavor.

Thanks so much Mark. Have a great weekend everyone !

Rob

Robert J. Muir, M.A.Sc., P.Eng.
Manager, Stormwater | Environmental Services
Community Services Commission | City of Markham
101 Town Center Blvd., Markham, Ontario L3R 9W3
Mobile: 416.991.2106| Email: rmuir@markham.ca
www.markham.ca

From: Mark Bassingthwaite <mbassingthwaite@resilientconsulting.ca>
Sent: Friday, January 20, 2023 3:56 PM
To: Muir, Robert <RMuir@markham.ca>
Cc: Saad Yousaf <saad.yousaf@vaughan.ca>; Andy Lee <andy.lee@vaughan.ca>; Rebecca Turbitt <rturbitt@resilientconsulting.ca>; Samantha Archibald <sarchibald@resilientconsulting.ca>
Subject: Non-Conventional SWMF Industry Scan

Good afternoon Rob,

Resilient Consulting is currently working with the City of Vaughan to develop a policy, procedure and relevant design criteria/standards for the approval of non-conventional municipal stormwater management facilities (SWMFs) associated with new development. The City, along with many neighbouring municipalities, is experiencing increased pressure to shift from requiring conventional municipal SWMFs (wet/dry ponds) towards accepting publicly owned and operated non-conventional SWMFs (underground storage tanks, superpipes, etc.), typically within new public park lands. The primary objectives in developing this framework for the City are:

- To provide a decision framework to determine where new non-conventional SWMFs may be accepted;
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- To provide a list of allowable stormwater management technologies/facility configurations that can be accepted as municipal facilities; and,
- To examine financial implications and lifecycle costs of implementing non-conventional SWMFs vs conventional faculties, and develop cost recovery mechanisms to be apply to subject developments to ensure implementation of non-conventional SWMFs are financially viable alternatives in the long-term.

At this time, approval of these non-conventional SWMFs has largely been completed on a case-by-case basis, taking into consideration feasibility, maintenance and operation requirements, and site specific design. An interim approach for accepting these non-conventional SWMFs was adopted by the City in 2022, however the goal is to have the new formal policy and procedures in place by the end of this year.

To support the development of this policy and procedure, we are reaching out to other municipalities to determine if any policies, procedures, design criteria or standards have been implemented within your municipality to address non-conventional SWMFs acceptance and implementation. Our goal in reviewing this information is to identify design approaches, considerations and data gaps within current non-conventional SWMFs practices which will be taken into consideration during the development of the City's formal policies and procedures. We would greatly appreciate if you could confirm if any of the above information is available within your municipality, and provide such information if possible.

If you are not the correct person to contact regarding this matter, could you please forward to the appropriate person?

Thank you for your assistance!

Mark

Mark Bassingthwaite, P.Eng.
Resilient Consulting
PO Box 643
Whitby, ON L1N 5V3
mbassingthwaite@resilientconsulting.ca
P: 289-943-4651
www.resilientconsulting.ca
@resilientccorp

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From: Muneef Ahmad
To: Mark Bassingthwaite
Cc: Saad Yousaf; Andy Lee; Samantha Archibald; Rebecca Turbitt; Jennifer Whittard
Subject: RE: Non-Conventional SWMF Industry Scan
Date: January 24, 2023 11:37:51 AM
Attachments: image001.png
image002.png

Good morning Mark,

Appreciate you reaching out. I believe I'd be the appropriate person at Mississauga that could speak to this.

Having said that, there isn't much to report actually. From past discussions with staff at Vaughan, we understand this pressure has been escalating around the GTA (e.g. thought I heard this inquiry from Oshawa as well, but could be mistaken). One of our key discussion points was the necessary inter-departmental dialogue that would be required to confirm how potential parkland credits would be handled. The nature of development is somewhat different in Mississauga from other municipalities as we don't have a lot of remaining greenfield development. The lakefront development we have does not require water quantity control so water quality and runoff volume reduction is being addressed through ROW LID and end-of-pipe OGS. As a function of these factors mentioned here, we've not found ourselves pressured to consider similar proposals for SWMF's under parks although we have constructed them ourselves as flood mitigation retrofit projects.

This is not to say it hasn't been asked in some form. Developers have asked us to consider LID on our roads to address their SWM requirements. It never got beyond my level, that is the developer didn't escalate. We've been standing firm so far that public lands are to serve communal function and are retained for the potential for any retrofit opportunities that may exist beyond subject development lands. Consequently, we don't have any relevant policies, procedures or standards that come to mind which speak to this inquiry.

Hoping this message may be helpful in some way. Do let me know if you think we could provide any further support. I'd certainly be interested to hear how this journey progresses.

Thank you very much,

MISSISSAUGA
Muneef Ahmad P.Eng
Manager-Stormwater Projects & Approvals, Environmental Services Section
T 905-615-3200 ext.4793
muneef.ahmad@mississauga.ca

City of Mississauga | Transportation & Works Department,
Infrastructure Planning & Engineering Services

Follow us on Instagram **@saugastormwater**

From: Mark Bassingthwaite <mbassingthwaite@resilientconsulting.ca>
Sent: Friday, January 20, 2023 3:58 PM
To: Muneef Ahmad <Muneef.Ahmad@mississauga.ca>
Cc: Saad Yousaf <saad.yousaf@vaughan.ca>; Andy Lee <andy.lee@vaughan.ca>; Samantha Archibald <sarchibald@resilientconsulting.ca>; Rebecca Turbitt <rturbitt@resilientconsulting.ca>; Jennifer Whittard <jwhittard@resilientconsulting.ca>
Subject: Non-Conventional SWMF Industry Scan

Good afternoon Muneef,

Resilient Consulting is currently working with the City of Vaughan to develop a policy, procedure and relevant design criteria/standards for the approval of non-conventional municipal stormwater management facilities (SWMFs) associated with new development. The City, along with many neighbouring municipalities, is experiencing increased pressure to shift from requiring conventional municipal SWMFs (wet/dry ponds) towards accepting publicly owned and operated non-conventional SWMFs (underground storage tanks, superpipes, etc.), typically within new public park lands. The primary objectives in developing this framework for the City are:

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implementation. Our goal in reviewing this information is to identify design approaches, considerations and data gaps within current non-conventional SWMFs practices which will be taken into consideration during the development of the City's formal policies and procedures. We would greatly appreciate if you could confirm if any of the above information is available within your municipality, and provide such information if possible.

If you are not the correct person to contact regarding this matter, could you please forward to the appropriate person?

Thank you for your assistance!

Mark

Mark Bassingthwaite, P.Eng.
Resilient Consulting
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Whitby, ON L1N 5V3
mbassingthwaite@resilientconsulting.ca
P: 289-943-4651
www.resilientconsulting.ca
@resilientccorp

Rebecca Turbitt

From: Daniels, Hanna <Hanna.Daniels@hamilton.ca>
Sent: February 9, 2023 10:16 AM
To: Mark Bassingthwaite
Cc: Saad Yousaf; Andy Lee; Rebecca Turbitt; Samantha Archibald; Jennifer Whittard
Subject: RE: Non-Conventional SWMF Industry Scan

Good morning Mark,

First, I have to say kudos to your Team and Vaughan for this work! I would be so happy to contribute, but I think you're at least a step or two ahead of us. We are in the process of developing Green Standards and Guidelines for private infrastructure, and will eventually get to standards for public infrastructure.

Similar to Vaughan, the implementation of non-conventional SWMFs on public lands/as City assets are assessed on a case by case basis. To be honest, those cases are not common but we approve them quite often on private property where they will remain private assets. We are in the process of kicking of a neighbourhood servicing/urbanization project that will require municipally owned non-conventional SWMFs, but it's still in its infancy and will be precedent setting for Hamilton Water. If you're interested, I can keep you posted on that work.

Sorry I couldn't provide more on this, but please do keep me in the loop as you progress and I will share our Green Standards and Guidelines for private developments once they're finalized (which is soon I hope).

Take care for now!
Hanna

Hanna Daniels
Senior Project Manager, Water/Wastewater Planning (Acting)
Public Works
Hamilton Water, City of Hamilton
(905) 546-2424 Ext.3421
Hamilton

From: Mark Bassingthwaite <mbassingthwaite@resilientconsulting.ca>
Sent: Wednesday, February 8, 2023 9:59 AM
To: Daniels, Hanna <Hanna.Daniels@hamilton.ca>
Cc: Saad Yousaf <saad.yousaf@vaughan.ca>; Andy Lee <andy.lee@vaughan.ca>; Rebecca Turbitt <rturbitt@resilientconsulting.ca>; Samantha Archibald <sarchibald@resilientconsulting.ca>; Jennifer Whittard <jwhittard@resilientconsulting.ca>
Subject: RE: Non-Conventional SWMF Industry Scan

Hi Hanna,

I am following up on the below email. We are hoping to obtain your feedback regarding the below in the next few days in order to finalize our background report.

Please let us know if you have any questions or are able to provide feedback.

Thank you,
Mark

From: Mark Bassingthwaite
Sent: January 20, 2023 3:59 PM
To: Daniels, Hanna <Hanna.Daniels@hamilton.ca>
Cc: Saad Yousaf <saad.yousaf@vaughan.ca>; Andy Lee <andy.lee@vaughan.ca>; Rebecca Turbitt <rturbitt@resilientconsulting.ca>; Samantha Archibald <sarchibald@resilientconsulting.ca>; Jennifer Whittard <jwhittard@resilientconsulting.ca>
Subject: Non-Conventional SWMF Industry Scan

Good afternoon Hanna,

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If you are not the correct person to contact regarding this matter, could you please forward to the appropriate person?

Thank you for your assistance!

Mark

Mark Bassingthwaite, P.Eng.
Resilient Consulting
PO Box 643

Whitby, ON L1N 5V3
mbassingthwaite@resilientconsulting.ca
P: 289-943-4651
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@resilientccorp

Rebecca Turbitt

From: Nick Gollan <Nick.Gollan@kitchener.ca>
Sent: February 9, 2023 4:05 PM
To: Mark Bassingthwaite
Cc: Saad Yousaf; Andy Lee; Samantha Archibald; Rebecca Turbitt; Jennifer Whittard; Travis Pawlick; Leah Walter
Subject: RE: Non-Conventional SWMF Industry Scan
Attachments: MUN-UTI-2003 - Stormwater Management Policy.pdf

Hi Mark,

I'm sorry for not getting back to you sooner. I have included Leah and Travis from Kitchener, who oversee operations and maintenance as well as environmental compliance, respectively.

We are interested in this work, particularly the outcomes, as we continually evolve our processes and keep the door open for innovative practices where appropriate.

I can say there are essentially five pillars we currently rely on to make decisions:

1) Integrated Stormwater Management Master Plan and the associated policy documents (infiltration in the context of source protection planning, minimum volume criteria and targets, stormwater management fee)
    - Overarching policy attached; master plan report available upon request
2) Consolidated Linear Infrastructure Environmental Compliance Approval issued by the Province to the City for the entire stormwater network
3) 2021 Development Manual
4) Operations and Maintenance standard operating procedures and best management practices
5) Stormwater Asset Management Plan

We currently have a non-prescriptive approach for when to accept “non-conventional” stormwater management approaches – as long as the outcomes and objectives of the aforementioned strategies are achieved by what is being proposed.

It might be worth having a structured conversation/meeting to share ideas.

Thanks for reaching out; as I mentioned, we are interested in following this work, providing valuable input, and using some appropriate recommendations for Kitchener.

Have a great afternoon.

Kind Regards,

Nick Gollan, C.E.T. (he/him)

Manager, Planning and Programs | Sanitary and Stormwater | City of Kitchener
519-741-2200 ext. 7422 | TTY 1-866-969-9994 | nick.gollan@kitchener.ca

From: Mark Bassingthwaite <mbassingthwaite@resilientconsulting.ca>
Sent: Wednesday, February 8, 2023 9:59 AM
To: Nick Gollan <Nick.Gollan@kitchener.ca>
Cc: Saad Yousaf <saad.yousaf@vaughan.ca>; Andy Lee <andy.lee@vaughan.ca>; Samantha Archibald <sarchibald@resilientconsulting.ca>; Rebecca Turbitt <rturbitt@resilientconsulting.ca>; Jennifer Whittard <jwhittard@resilientconsulting.ca>
Subject: RE: Non-Conventional SWMF Industry Scan

Hi Nick,

I am following up on the below email. We are hoping to obtain your feedback regarding the below in the next few days in order to finalize our background report.

Please let us know if you have any questions or are able to provide feedback.

Thank you,
Mark

Mark Bassingthwaite, P.Eng.
Resilient Consulting
PO Box 643
Whitby, ON L1N 5V3
mbassingthwaite@resilientconsulting.ca
P: 289-943-4651
www.resilientconsulting.ca
@resilientccorp

From: Mark Bassingthwaite
Sent: January 20, 2023 4:21 PM
To: nick.gollan@kitchener.ca
Cc: Saad Yousaf <saad.yousaf@vaughan.ca>; Andy Lee <andy.lee@vaughan.ca>; Samantha Archibald <sarchibald@resilientconsulting.ca>; Rebecca Turbitt <rturbitt@resilientconsulting.ca>; Jennifer Whittard <jwhittard@resilientconsulting.ca>
Subject: Non-Conventional SWMF Industry Scan

Good afternoon Nick,

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If you are not the correct person to contact regarding this matter, could you please forward to the appropriate person?

Thank you for your assistance!

Mark

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Whitby, ON L1N 5V3
mbassingthwaite@resilientconsulting.ca
P: 289-943-4651
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@resilientccorp

Rebecca Turbitt

From: Malik, Umar <Umar.Malik@burlington.ca>
Sent: February 8, 2023 1:19 PM
To: Mark Bassingthwaite; Shahzad, Arif
Cc: Saad Yousaf; Andy Lee; Samantha Archibald; Rebecca Turbitt; Jennifer Whittard
Subject: RE: Non-Conventional SWMF Industry Scan
Attachments: 2020-STORM DESIGN MANUAL.pdf

Good afternoon Mark,

I hope you are doing well.

Attached is the City of Burlington's most recent Stormwater Management Guidelines document. It was prepared in 2020. We follow this to review the development applications and approve stormwater management systems and infrastructure. I hope it will provide you with the information you are looking for.

Regards,

Umar Malik, M.Eng., P.Eng.
Stormwater Engineer
Engineering Services
P. 905-335-7600, ext 7426| **E.** umar.malik@burlington.ca
Address 426 Brant Street P.O. Box 5013, Burlington, Ontario, L7R 3Z6
City of Burlington | www.burlington.ca

From: Mark Bassingthwaite <mbassingthwaite@resilientconsulting.ca>
Sent: Wednesday, February 08, 2023 10:00 AM
To: Shahzad, Arif <Arif.Shahzad@burlington.ca>; Malik, Umar <Umar.Malik@burlington.ca>
Cc: Saad Yousaf <saad.yousaf@vaughan.ca>; Andy Lee <andy.lee@vaughan.ca>; Samantha Archibald <sarchibald@resilientconsulting.ca>; Rebecca Turbitt <rturbitt@resilientconsulting.ca>; Jennifer Whittard <jwhittard@resilientconsulting.ca>
Subject: RE: Non-Conventional SWMF Industry Scan

Hi Umar,

I am following up on the below email. We are hoping to obtain your feedback regarding the below in the next few days in order to finalize our background report.

Please let us know if you have any questions or are able to provide feedback.

Thank you,
Mark

From: Shahzad, Arif <Arif.Shahzad@burlington.ca>
Sent: January 23, 2023 9:51 AM
To: Mark Bassingthwaite <mbassingthwaite@resilientconsulting.ca>; Malik, Umar <Umar.Malik@burlington.ca>
Cc: Saad Yousaf <saad.yousaf@vaughan.ca>; Andy Lee <andy.lee@vaughan.ca>; Samantha Archibald <sarchibald@resilientconsulting.ca>; Rebecca Turbitt <rturbitt@resilientconsulting.ca>; Jennifer Whittard <jwhittard@resilientconsulting.ca>
Subject: RE: Non-Conventional SWMF Industry Scan

Hi Mark: I have copied Umar Malik on this email. He is more involved in the SWM reviews related to new developments and may be able to provide his insight on this matter.
Thank you,

Arif Shahzad, M.Eng., P.Eng.
Senior Project Manager - Stormwater Engineering
Engineering Services

P. 905-335-7600 ext. 7486| **E**. Arif.Shahzad@burlington.ca
Address 426 Brant Street P.O.Box 5013, Burlington, Ontario, L7R 3Z6
City of Burlington| www.burlington.ca

From: Mark Bassingthwaite <mbassingthwaite@resilientconsulting.ca>
Sent: Friday, January 20, 2023 4:00 PM
To: Shahzad, Arif <Arif.Shahzad@burlington.ca>
Cc: Saad Yousaf <saad.yousaf@vaughan.ca>; Andy Lee <andy.lee@vaughan.ca>; Samantha Archibald <sarchibald@resilientconsulting.ca>; Rebecca Turbitt <rturbitt@resilientconsulting.ca>; Jennifer Whittard <jwhittard@resilientconsulting.ca>
Subject: Non-Conventional SWMF Industry Scan

Good afternoon Arif,

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If you are not the correct person to contact regarding this matter, could you please forward to the appropriate person?

Thank you for your assistance!

Mark

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Whitby, ON L1N 5V3
mbassingthwaite@resilientconsulting.ca
P: 289-943-4651
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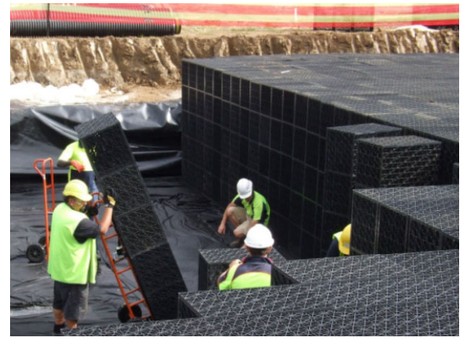
APPENDIX C

Summary Table of Non-Conventional SWMF

No.	Option	Examples	Description	Advantages	Disadvantages	Capital Cost	Maintenance Procedures / Requirements	Rating	Photos
1	"Milk-Crate" System	• Atlantis Matrix Tank. • Brentwood StormTank Module. • EcoRain Tanks. • Ausdrain EnviroModule 2. • Stormcon Greenstorm Module.	• Stackable, modular HDPE chambers in a shape similar to milk crates, designed to detain and/or retain stormwater on site. • Can be configured to infiltrate or lined to limit infiltration. • Sections of the crates snap together and are assembled on site.	• Higher void ratio compared to arch chambers, exceeding 95% in most cases. • Easy installation. • Suitable for use in parks and other land uses with little to no vehicular traffic. • Easily packaged and shipped. • Opportunity for infiltration.	• Groundwater elevation will be a constraint. • More expensive than arch chambers. • Not as commonplace as arch chambers in this area, contractors may not be as familiar. • Cannot enter main system. Therefore no opportunities for maintenance without excavation. • Little opportunity to provide quality control.	• Roughly $500 per m^3 of storage installed.	• Semi-annual inspection for first years and after every large event. • Annual visual inspection through inspection ports. • CSE not required for inspection – entry not possible. • Use for VacTruck/pump to remove sediment and flush until discharge is clean. • Can incorporate a pre-treatment element to capture most sediment/debris in an easier to maintain location.	Functional ★★★ Suitability ★★★★ Capital Cost ★★★ Maintenance ★★ **Overall** ★★★	
2	Plastic Arch Chambers	• Terrafix Triton System • StormTech Chambers • Soleno Hydrostor and Stormchamber Systems • Cultec chambers	• Modular arch plastic chambers designed to detain and/or retain stormwater on site. • Can be configured to infiltration or lined to limit infiltration. • Sections of the chambers snap together and are assembled on site. • Some products allow for "stacked" configuration.	• More void space for storage compared to subsurface infiltration trenches. • Header row for quality control can be easily incorporated into design. • Suitable for use in parks and other land uses with little to no vehicular traffic. • Easy shipping and installation. • Generally cheaper than milk crate systems. • Access ports can be installed for maintenance and flushing. • Opportunity for infiltration.	• Groundwater elevation will be a constraint. • Less void space than milk crate system. • Maintenance can be difficult, especially for smaller units. Larger units can be entered.	• Roughly $250 per m^3 of storage installed.	• Semi-annual inspection for first year. • Annual visual inspection through inspection ports. • CSE not required for inspection – entry possible on larger structures. • Vacuum/JetVac Process used to remove sediment upon accum. of 3". • CSE required if maintenance on chambers required. • Selection of vacuum/JetVac truck and nozzles key for proper maintenance. • Can incorporate a pre-treatment element.	Functional ★★★★ Suitability ★★★★ Capital Cost ★★★★ Maintenance ★★★ **Overall** ★★★★	
3	Modular Concrete Chambers	• StormTrap System • Contech Terre Arch and CON/SPAN Detention System • DECAST I-Storm	• Precast, modular concrete storage units installed underground, typically under parking lots. • Sections of arches are pieced together, can be grouted if necessary. • Can be configured to infiltrate or lined to limit infiltration.	• Higher load bearing capacity compared to plastic systems. • Large void spaces. • Opportunity for infiltration. • Can easily configure conc. chambers for long flow path for quality benefits. • Can achieve larger depths compared to plastic, meaning smaller facility footprints. • Many units are designed for confined space entry, which allows for more flexible maintenance /rehabilitation. • Simple shipping and installation, though more expensive that its plastic counterparts.	• Load bearing capacity of the concrete structure largely wasted on parks when little to no vehicular traffic is expected. • Shipment more difficult than plastic storage systems. • More expensive than plastic storage systems.	• Expensive. Up to $1,000 per m^3.	• Minimum annual inspection or after large storm events / rainy seasons. CSE not required for inspection. • Maintenance required when sediment occupies 15% of design volume. • Use of VacTruck to remove sediment. • CSE not required for maintenance – entry is possible if needed. • Maintenance frequency typically 5-10 years for dry vaults and 3-5 years for wet vault.	Functional ★★★★★ Suitability ★★★ Capital Cost ★★ Maintenance ★★★ **Overall** ★★★	

No.	Option	Examples	Description	Advantages	Disadvantages	Capital Cost	Maintenance Procedures / Requirements	Rating	Photos
4	Superpipes	• Soleno Solflo and Weholite Detention Systems. • ADS N-12 Pipe Retention System. • Contech CMP and Duromaxx Systems	• Large diameter pipes connected to form a large, underground storage chamber. • Typically made from CMP or HDPE pipes.	• No constraints from groundwater. • Easy installation. • Suitable for use in parks and other land uses. • Pipes will be large enough for confined space entry, which allows for more flexible maintenance/ rehabilitation. • Simple shipping and installation.	• Marginal water quality benefits. • High material costs. • No opportunity for infiltration.	• Large diameter superpipes can be expensive. • Approximately $2000/m^3 installed	• Access manhole provided at upstream and downstream ends for inspection/maintenance. • CSE not required for maintenance – entry possible if needed. • Flushing and sediment removal required using high pressure water and Hydrovac Truck. • Can incorporate a pre-treatment element to capture most sediment/debris in an easier to maintain location.	Functional ★★★ Suitability ★★★★ Capital Cost ★ Maintenance ★★★★ **Overall** ★★★	
5	Cast-in-place Concrete Facility	• Concrete suppliers / general contractor	• Construct a large cast-in-place concrete, underground storage facility.	• Large void spaces. • Can incorporate baffles to quality control benefits. • No constraints from groundwater. • Easily accessible with confined space entry, which allows for more flexible maintenance/ rehabilitation. • Can achieve larger depths compared to other options, meaning smaller facility footprints.	• No opportunity for infiltration. • Very expensive. • More complex construction.	• Expensive. Up to $1,000 per m^3. • During winter months, may require heating when pouring.	• Access manhole provided for inspection and maintenance. • Measure sediment depth using rod on an annual basis. • Hydrovac Truck used to remove sediment/debris. • CSE not required for maintenance – entry possible if needed.	Functional ★★★★★ Suitability ★ Capital Cost ★★ Maintenance ★★★ **Overall** ★★	
6	Modular Form Cast-in-place Concrete	• Cupolex Rialto Stormwater Tanks	• Cast-in-place concrete tank system designed to detain and/or retain runoff. • Plastic forming network snaps together on-site, concrete poured over top to fill forms.	• Large void ratio at 98%. • Minimal cover required, ideal for park applications with minimal vehicular traffic. • Opportunity for infiltration. • Simple shipping and placing form. • Easily accessible with confined space entry, which allows for more flexible maintenance/ rehabilitation.	• Groundwater elevation may be a constraint. • Increased construction time for concrete to cure. • Cannot enter main storage. Future concrete/crack repairs could be done by machine, similar to sewer repairs. • Not as commonplace as arch chambers in this area, contractors may not be as familiar.	• Roughly $250 per m^3 of storage installed.	• Access hatches provided to perform inspections and maintenance. • Inspection well provided in tank to allow for ease of inspection. • Maintenance required when sediment depth reaches 3”. • Sediment removed using high pressure water and Hydrovac truck. • Yearly visual inspection, maintenance every 9-years. • Can incorporate a pre-treatment element. • CSE not required for regular maintenance – entry possible if needed.	Functional ★★★★★ Suitability ★★★★ Capital Cost ★★★★ Maintenance ★★★ **Overall** ★★★★	

APPENDIX D

Lifecycle Assessment

Gallanough Park SWMF Class EA Addendum
Client: City of Vaughan
Project No: 2020-010
Date: 10-Feb-23
Prepared By: RJT

Cost Estimates

Capital Cost (Assuming 10,000 m^3 facility)

Alt. #	Description	Cost
1	Milk-Crate	$5,000,000.00
2	Plastic Arch	$2,500,000.00
3	Modular Conc. Chamber	$10,000,000.00
4	Super Pipe	$20,000,000.00
5	Cast-in-place Conc.	$10,000,000.00
6	Modular Form Cast-in-place	$2,500,000.00

Equivalent Annual Maintenance Cost

Alt. #	Description	Cost
1	Milk-Crate	$13,000.00
2	Plastic Arch	$13,000.00
3	Modular Conc. Chamber	$21,320.00
4	Super Pipe	$13,000.00
5	Cast-in-place Conc.	$21,320.00
6	Modular Form Cast-in-place	$21,320.00

Maintenance Cost Net Present Value Analysis (100 years, 3%)

Alt. #	Description	Cost
1	Milk-Crate*	$902,465.99
2	Plastic Arch*	$902,465.99
3	Modular Conc. Chamber	$512,469.96
4	Super Pipe	$332,198.29
5	Cast-in-place Conc.	$512,469.96
6	Modular Form Cast-in-place	$512,469.96

* Includes replacement fee at 50 years

Total Value Analysis

Alt. #	Description	Cost
1	Milk-Crate	$5,902,465.99
2	Plastic Arch	$3,402,465.99
3	Modular Conc. Chamber	$10,512,469.96
4	Super Pipe	$20,332,198.29
5	Cast-in-place Conc.	$10,512,469.96
6	Modular Form Cast-in-place	$3,012,469.96

RESILIENT CONSULTING

Non-Conventional SWMF Assessment

Client:	City of Vaughan
Project No:	2023-001
Date:	10-Feb-23
Prepared By:	RJT

Annual Maintenance Costs

Alternative	Facility Type	Life Expectancy	Visual Inspection	Surface Debris Removal	CSE Inspection	Debris Removal from Facility	Concrete Repairs	Total Projected Cost/Year
		Frequency	*Annual*	*Annual*	*25 Years*	*5 Years*	*25 Years*	
1	Milk-crate System	50	$ 2,500.00	$ 2,000.00		$ 30,000.00		$ 13,000.00
2	Plastic Arch System	50	$ 2,500.00	$ 2,000.00		$ 30,000.00		$ 13,000.00
3	Modular Conc. Chamber	100	$ 2,500.00	$ 2,000.00	$ 8,000.00	$ 30,000.00	$ 200,000.00	$ 21,320.00
4	Super Pipes	100	$ 2,500.00	$ 2,000.00		$ 30,000.00		$ 13,000.00
5	Cast-in place Conc.	100	$ 2,500.00	$ 2,000.00	$ 8,000.00	$ 30,000.00	$ 200,000.00	$ 21,320.00
6	Modular Form Cast-in-place	100	$ 2,500.00	$ 2,000.00	$ 8,000.00	$ 30,000.00	$ 200,000.00	$ 21,320.00

Notes:

- Assessment completed based on a 100-year duration, at a 3% interest rate
- Assessment includes replacement at end of life of plastic factilities
- Replacement costs are highly variable and are assumed at the lowest capital cost for the plastic facilities
- Underground Debris removal includes use of VacTruck/Flusher/High-pressure Water
- Frequency of Debris Removal is dependent on the sediment loading from the catchment. 5 Year frequency conservatively assumed
- Visual Inspection to occur semi-annually for the first 5-years

Interest rate **0.03**

Year	Visual Inspection	CSE Inspection	Surface Debris	U/G Debris	Concrete Repairs	Replacement	Alt 1	Discounted Cash	Alt 2	Discounted Cash	Alt 3	Discounted Cash	Alt 4	Discounted Cash	Alt 5	Discounted Cash	Alt 6	Discounted Cash
1	$ 5,000.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 7,000.00	$ 6,796.12	$ 7,000.00	$ 6,796.12	$ 7,000.00	$ 6,796.12	$ 7,000.00	$ 6,796.12	$ 7,000.00	$ 6,796.12	$ 7,000.00	$ 6,796.12
2	$ 5,000.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 7,000.00	$ 6,598.17	$ 7,000.00	$ 6,598.17	$ 7,000.00	$ 6,598.17	$ 7,000.00	$ 6,598.17	$ 7,000.00	$ 6,598.17	$ 7,000.00	$ 6,598.17
3	$ 5,000.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 7,000.00	$ 6,405.99	$ 7,000.00	$ 6,405.99	$ 7,000.00	$ 6,405.99	$ 7,000.00	$ 6,405.99	$ 7,000.00	$ 6,405.99	$ 7,000.00	$ 6,405.99
4	$ 5,000.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 7,000.00	$ 6,219.41	$ 7,000.00	$ 6,219.41	$ 7,000.00	$ 6,219.41	$ 7,000.00	$ 6,219.41	$ 7,000.00	$ 6,219.41	$ 7,000.00	$ 6,219.41
5	$ 5,000.00	$ -	$ 2,000.00	$ 30,000.00	$ -	$ -	$ 37,000.00	$ 31,916.53	$ 37,000.00	$ 31,916.53	$ 37,000.00	$ 31,916.53	$ 37,000.00	$ 31,916.53	$ 37,000.00	$ 31,916.53	$ 37,000.00	$ 31,916.53
6	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 3,768.68	$ 4,500.00	$ 3,768.68	$ 4,500.00	$ 3,768.68	$ 4,500.00	$ 3,768.68	$ 4,500.00	$ 3,768.68	$ 4,500.00	$ 3,768.68
7	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 3,658.91	$ 4,500.00	$ 3,658.91	$ 4,500.00	$ 3,658.91	$ 4,500.00	$ 3,658.91	$ 4,500.00	$ 3,658.91	$ 4,500.00	$ 3,658.91
8	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 3,552.34	$ 4,500.00	$ 3,552.34	$ 4,500.00	$ 3,552.34	$ 4,500.00	$ 3,552.34	$ 4,500.00	$ 3,552.34	$ 4,500.00	$ 3,552.34
9	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 3,448.88	$ 4,500.00	$ 3,448.88	$ 4,500.00	$ 3,448.88	$ 4,500.00	$ 3,448.88	$ 4,500.00	$ 3,448.88	$ 4,500.00	$ 3,448.88
10	$ 2,500.00	$ -	$ 2,000.00	$ 30,000.00	$ -	$ -	$ 34,500.00	$ 25,671.24	$ 34,500.00	$ 25,671.24	$ 34,500.00	$ 25,671.24	$ 34,500.00	$ 25,671.24	$ 34,500.00	$ 25,671.24	$ 34,500.00	$ 25,671.24
11	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 3,250.90	$ 4,500.00	$ 3,250.90	$ 4,500.00	$ 3,250.90	$ 4,500.00	$ 3,250.90	$ 4,500.00	$ 3,250.90	$ 4,500.00	$ 3,250.90
12	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 3,156.21	$ 4,500.00	$ 3,156.21	$ 4,500.00	$ 3,156.21	$ 4,500.00	$ 3,156.21	$ 4,500.00	$ 3,156.21	$ 4,500.00	$ 3,156.21
13	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 3,064.28	$ 4,500.00	$ 3,064.28	$ 4,500.00	$ 3,064.28	$ 4,500.00	$ 3,064.28	$ 4,500.00	$ 3,064.28	$ 4,500.00	$ 3,064.28
14	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 2,975.03	$ 4,500.00	$ 2,975.03	$ 4,500.00	$ 2,975.03	$ 4,500.00	$ 2,975.03	$ 4,500.00	$ 2,975.03	$ 4,500.00	$ 2,975.03
15	$ 2,500.00	$ -	$ 2,000.00	$ 30,000.00	$ -	$ -	$ 34,500.00	$ 22,144.24	$ 34,500.00	$ 22,144.24	$ 34,500.00	$ 22,144.24	$ 34,500.00	$ 22,144.24	$ 34,500.00	$ 22,144.24	$ 34,500.00	$ 22,144.24
16	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 2,804.25	$ 4,500.00	$ 2,804.25	$ 4,500.00	$ 2,804.25	$ 4,500.00	$ 2,804.25	$ 4,500.00	$ 2,804.25	$ 4,500.00	$ 2,804.25
17	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 2,722.57	$ 4,500.00	$ 2,722.57	$ 4,500.00	$ 2,722.57	$ 4,500.00	$ 2,722.57	$ 4,500.00	$ 2,722.57	$ 4,500.00	$ 2,722.57
18	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 2,643.28	$ 4,500.00	$ 2,643.28	$ 4,500.00	$ 2,643.28	$ 4,500.00	$ 2,643.28	$ 4,500.00	$ 2,643.28	$ 4,500.00	$ 2,643.28
19	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 2,566.29	$ 4,500.00	$ 2,566.29	$ 4,500.00	$ 2,566.29	$ 4,500.00	$ 2,566.29	$ 4,500.00	$ 2,566.29	$ 4,500.00	$ 2,566.29
20	$ 2,500.00	$ -	$ 2,000.00	$ 30,000.00	$ -	$ -	$ 34,500.00	$ 19,101.81	$ 34,500.00	$ 19,101.81	$ 34,500.00	$ 19,101.81	$ 34,500.00	$ 19,101.81	$ 34,500.00	$ 19,101.81	$ 34,500.00	$ 19,101.81
21	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 2,418.97	$ 4,500.00	$ 2,418.97	$ 4,500.00	$ 2,418.97	$ 4,500.00	$ 2,418.97	$ 4,500.00	$ 2,418.97	$ 4,500.00	$ 2,418.97
22	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 2,348.52	$ 4,500.00	$ 2,348.52	$ 4,500.00	$ 2,348.52	$ 4,500.00	$ 2,348.52	$ 4,500.00	$ 2,348.52	$ 4,500.00	$ 2,348.52
23	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 2,280.11	$ 4,500.00	$ 2,280.11	$ 4,500.00	$ 2,280.11	$ 4,500.00	$ 2,280.11	$ 4,500.00	$ 2,280.11	$ 4,500.00	$ 2,280.11
24	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 2,213.70	$ 4,500.00	$ 2,213.70	$ 4,500.00	$ 2,213.70	$ 4,500.00	$ 2,213.70	$ 4,500.00	$ 2,213.70	$ 4,500.00	$ 2,213.70
25	$ 2,500.00	$ 8,000.00	$ 2,000.00	$ 30,000.00	$ 200,000.00	$ -	$ 34,500.00	$ 16,477.39	$ 34,500.00	$ 16,477.39	$ 242,500.00	$ 115,819.35	$ 34,500.00	$ 16,477.39	$ 242,500.00	$ 115,819.35	$ 242,500.00	$ 115,819.35
26	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 2,086.63	$ 4,500.00	$ 2,086.63	$ 4,500.00	$ 2,086.63	$ 4,500.00	$ 2,086.63	$ 4,500.00	$ 2,086.63	$ 4,500.00	$ 2,086.63
27	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 2,025.85	$ 4,500.00	$ 2,025.85	$ 4,500.00	$ 2,025.85	$ 4,500.00	$ 2,025.85	$ 4,500.00	$ 2,025.85	$ 4,500.00	$ 2,025.85
28	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 1,966.85	$ 4,500.00	$ 1,966.85	$ 4,500.00	$ 1,966.85	$ 4,500.00	$ 1,966.85	$ 4,500.00	$ 1,966.85	$ 4,500.00	$ 1,966.85
29	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 1,909.56	$ 4,500.00	$ 1,909.56	$ 4,500.00	$ 1,909.56	$ 4,500.00	$ 1,909.56	$ 4,500.00	$ 1,909.56	$ 4,500.00	$ 1,909.56
30	$ 2,500.00	$ -	$ 2,000.00	$ 30,000.00	$ -	$ -	$ 34,500.00	$ 14,213.54	$ 34,500.00	$ 14,213.54	$ 34,500.00	$ 14,213.54	$ 34,500.00	$ 14,213.54	$ 34,500.00	$ 14,213.54	$ 34,500.00	$ 14,213.54
31	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 1,799.94	$ 4,500.00	$ 1,799.94	$ 4,500.00	$ 1,799.94	$ 4,500.00	$ 1,799.94	$ 4,500.00	$ 1,799.94	$ 4,500.00	$ 1,799.94
32	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 1,747.52	$ 4,500.00	$ 1,747.52	$ 4,500.00	$ 1,747.52	$ 4,500.00	$ 1,747.52	$ 4,500.00	$ 1,747.52	$ 4,500.00	$ 1,747.52
33	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 1,696.62	$ 4,500.00	$ 1,696.62	$ 4,500.00	$ 1,696.62	$ 4,500.00	$ 1,696.62	$ 4,500.00	$ 1,696.62	$ 4,500.00	$ 1,696.62
34	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 1,647.20	$ 4,500.00	$ 1,647.20	$ 4,500.00	$ 1,647.20	$ 4,500.00	$ 1,647.20	$ 4,500.00	$ 1,647.20	$ 4,500.00	$ 1,647.20
35	$ 2,500.00	$ -	$ 2,000.00	$ 30,000.00	$ -	$ -	$ 34,500.00	$ 12,260.73	$ 34,500.00	$ 12,260.73	$ 34,500.00	$ 12,260.73	$ 34,500.00	$ 12,260.73	$ 34,500.00	$ 12,260.73	$ 34,500.00	$ 12,260.73
36	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 1,552.65	$ 4,500.00	$ 1,552.65	$ 4,500.00	$ 1,552.65	$ 4,500.00	$ 1,552.65	$ 4,500.00	$ 1,552.65	$ 4,500.00	$ 1,552.65
37	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 1,507.42	$ 4,500.00	$ 1,507.42	$ 4,500.00	$ 1,507.42	$ 4,500.00	$ 1,507.42	$ 4,500.00	$ 1,507.42	$ 4,500.00	$ 1,507.42
38	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 1,463.52	$ 4,500.00	$ 1,463.52	$ 4,500.00	$ 1,463.52	$ 4,500.00	$ 1,463.52	$ 4,500.00	$ 1,463.52	$ 4,500.00	$ 1,463.52
39	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 1,420.89	$ 4,500.00	$ 1,420.89	$ 4,500.00	$ 1,420.89	$ 4,500.00	$ 1,420.89	$ 4,500.00	$ 1,420.89	$ 4,500.00	$ 1,420.89
40	$ 2,500.00	$ -	$ 2,000.00	$ 30,000.00	$ -	$ -	$ 34,500.00	$ 10,576.21	$ 34,500.00	$ 10,576.21	$ 34,500.00	$ 10,576.21	$ 34,500.00	$ 10,576.21	$ 34,500.00	$ 10,576.21	$ 34,500.00	$ 10,576.21
41	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 1,339.33	$ 4,500.00	$ 1,339.33	$ 4,500.00	$ 1,339.33	$ 4,500.00	$ 1,339.33	$ 4,500.00	$ 1,339.33	$ 4,500.00	$ 1,339.33
42	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 1,300.32	$ 4,500.00	$ 1,300.32	$ 4,500.00	$ 1,300.32	$ 4,500.00	$ 1,300.32	$ 4,500.00	$ 1,300.32	$ 4,500.00	$ 1,300.32
43	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 1,262.44	$ 4,500.00	$ 1,262.44	$ 4,500.00	$ 1,262.44	$ 4,500.00	$ 1,262.44	$ 4,500.00	$ 1,262.44	$ 4,500.00	$ 1,262.44
44	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 1,225.67	$ 4,500.00	$ 1,225.67	$ 4,500.00	$ 1,225.67	$ 4,500.00	$ 1,225.67	$ 4,500.00	$ 1,225.67	$ 4,500.00	$ 1,225.67
45	$ 2,500.00	$ -	$ 2,000.00	$ 30,000.00	$ -	$ -	$ 34,500.00	$ 9,123.13	$ 34,500.00	$ 9,123.13	$ 34,500.00	$ 9,123.13	$ 34,500.00	$ 9,123.13	$ 34,500.00	$ 9,123.13	$ 34,500.00	$ 9,123.13
46	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 1,155.31	$ 4,500.00	$ 1,155.31	$ 4,500.00	$ 1,155.31	$ 4,500.00	$ 1,155.31	$ 4,500.00	$ 1,155.31	$ 4,500.00	$ 1,155.31
47	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 1,121.66	$ 4,500.00	$ 1,121.66	$ 4,500.00	$ 1,121.66	$ 4,500.00	$ 1,121.66	$ 4,500.00	$ 1,121.66	$ 4,500.00	$ 1,121.66
48	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 1,088.99	$ 4,500.00	$ 1,088.99	$ 4,500.00	$ 1,088.99	$ 4,500.00	$ 1,088.99	$ 4,500.00	$ 1,088.99	$ 4,500.00	$ 1,088.99
49	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 1,057.28	$ 4,500.00	$ 1,057.28	$ 4,500.00	$ 1,057.28	$ 4,500.00	$ 1,057.28	$ 4,500.00	$ 1,057.28	$ 4,500.00	$ 1,057.28
50	$ 2,500.00	$ 8,000.00	$ 2,000.00	$ 30,000.00	$ 200,000.00	$ 2,500,000.00	$ 2,534,500.00	$ 578,137.39	$ 2,534,500.00	$ 578,137.39	$ 242,500.00	$ 55,315.97	$ 34,500.00	$ 7,869.69	$ 242,500.00	$ 55,315.97	$ 242,500.00	$ 55,315.97
51	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 996.58	$ 4,500.00	$ 996.58	$ 4,500.00	$ 996.58	$ 4,500.00	$ 996.58	$ 4,500.00	$ 996.58	$ 4,500.00	$ 996.58
52	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 967.56	$ 4,500.00	$ 967.56	$ 4,500.00	$ 967.56	$ 4,500.00	$ 967.56	$ 4,500.00	$ 967.56	$ 4,500.00	$ 967.56
53	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 939.38	$ 4,500.00	$ 939.38	$ 4,500.00	$ 939.38	$ 4,500.00	$ 939.38	$ 4,500.00	$ 939.38	$ 4,500.00	$ 939.38
54	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 912.02	$ 4,500.00	$ 912.02	$ 4,500.00	$ 912.02	$ 4,500.00	$ 912.02	$ 4,500.00	$ 912.02	$ 4,500.00	$ 912.02
55	$ 2,500.00	$ -	$ 2,000.00	$ 30,000.00	$ -	$ -	$ 34,500.00	$ 6,788.47	$ 34,500.00	$ 6,788.47	$ 34,500.00	$ 6,788.47	$ 34,500.00	$ 6,788.47	$ 34,500.00	$ 6,788.47	$ 34,500.00	$ 6,788.47
56	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 859.66	$ 4,500.00	$ 859.66	$ 4,500.00	$ 859.66	$ 4,500.00	$ 859.66	$ 4,500.00	$ 859.66	$ 4,500.00	$ 859.66
57	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 834.62	$ 4,500.00	$ 834.62	$ 4,500.00	$ 834.62	$ 4,500.00	$ 834.62	$ 4,500.00	$ 834.62	$ 4,500.00	$ 834.62
58	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 810.31	$ 4,500.00	$ 810.31	$ 4,500.00	$ 810.31	$ 4,500.00	$ 810.31	$ 4,500.00	$ 810.31	$ 4,500.00	$ 810.31
59	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 786.71	$ 4,500.00	$ 786.71	$ 4,500.00	$ 786.71	$ 4,500.00	$ 786.71	$ 4,500.00	$ 786.71	$ 4,500.00	$ 786.71
60	$ 2,500.00	$ -	$ 2,000.00	$ 30,000.00	$ -	$ -	$ 34,500.00	$ 5,855.79	$ 34,500.00	$ 5,855.79	$ 34,500.00	$ 5,855.79	$ 34,500.00	$ 5,855.79	$ 34,500.00	$ 5,855.79	$ 34,500.00	$ 5,855.79
61	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 741.55	$ 4,500.00	$ 741.55	$ 4,500.00	$ 741.55	$ 4,500.00	$ 741.55	$ 4,500.00	$ 741.55	$ 4,500.00	$ 741.55
62	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 719.95	$ 4,500.00	$ 719.95	$ 4,500.00	$ 719.95	$ 4,500.00	$ 719.95	$ 4,500.00	$ 719.95	$ 4,500.00	$ 719.95
63	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 698.98	$ 4,500.00	$ 698.98	$ 4,500.00	$ 698.98	$ 4,500.00	$ 698.98	$ 4,500.00	$ 698.98	$ 4,500.00	$ 698.98
64	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 678.63	$ 4,500.00	$ 678.63	$ 4,500.00	$ 678.63	$ 4,500.00	$ 678.63	$ 4,500.00	$ 678.63	$ 4,500.00	$ 678.63
65	$ 2,500.00	$ -	$ 2,000.00	$ 30,000.00	$ -	$ -	$ 34,500.00	$ 5,051.26	$ 34,500.00	$ 5,051.26	$ 34,500.00	$ 5,051.26	$ 34,500.00	$ 5,051.26	$ 34,500.00	$ 5,051.26	$ 34,500.00	$ 5,051.26
66	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 639.67	$ 4,500.00	$ 639.67	$ 4,500.00	$ 639.67	$ 4,500.00	$ 639.67	$ 4,500.00	$ 639.67	$ 4,500.00	$ 639.67
67	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 621.04	$ 4,500.00	$ 621.04	$ 4,500.00	$ 621.04	$ 4,500.00	$ 621.04	$ 4,500.00	$ 621.04	$ 4,500.00	$ 621.04
68	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 602.95	$ 4,500.00	$ 602.95	$ 4,500.00	$ 602.95	$ 4,500.00	$ 602.95	$ 4,500.00	$ 602.95	$ 4,500.00	$ 602.95
69	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 585.39	$ 4,500.00	$ 585.39	$ 4,500.00	$ 585.39	$ 4,500.00	$ 585.39	$ 4,500.00	$ 585.39	$ 4,500.00	$ 585.39
70	$ 2,500.00	$ -	$ 2,000.00	$ 30,000.00	$ -	$ -	$ 34,500.00	$ 4,357.26	$ 34,500.00	$ 4,357.26	$ 34,500.00	$ 4,357.26	$ 34,500.00	$ 4,357.26	$ 34,500.00	$ 4,357.26	$ 34,500.00	$ 4,357.26

71	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 551.78	$ 4,500.00	$ 551.78	$ 4,500.00	$ 551.78	$ 4,500.00	$ 551.78	$ 4,500.00	$ 551.78	$ 4,500.00	$ 551.78	$ 4,500.00	$ 551.78	$ 4,500.00	$ 551.78
72	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 535.71	$ 4,500.00	$ 535.71	$ 4,500.00	$ 535.71	$ 4,500.00	$ 535.71	$ 4,500.00	$ 535.71	$ 4,500.00	$ 535.71	$ 4,500.00	$ 535.71	$ 4,500.00	$ 535.71
73	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 520.11	$ 4,500.00	$ 520.11	$ 4,500.00	$ 520.11	$ 4,500.00	$ 520.11	$ 4,500.00	$ 520.11	$ 4,500.00	$ 520.11	$ 4,500.00	$ 520.11	$ 4,500.00	$ 520.11
74	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 504.96	$ 4,500.00	$ 504.96	$ 4,500.00	$ 504.96	$ 4,500.00	$ 504.96	$ 4,500.00	$ 504.96	$ 4,500.00	$ 504.96	$ 4,500.00	$ 504.96	$ 4,500.00	$ 504.96
75	$ 2,500.00	$ 8,000.00	$ 2,000.00	$ 30,000.00	$ 200,000.00	$ -	$ 34,500.00	$ 3,758.61	$ 34,500.00	$ 3,758.61	$ 242,500.00	$ 26,419.21	$ 34,500.00	$ 3,758.61	$ 242,500.00	$ 26,419.21	$ 242,500.00	$ 26,419.21	$ 34,500.00	$ 3,758.61	$ 242,500.00	$ 26,419.21
76	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 475.97	$ 4,500.00	$ 475.97	$ 4,500.00	$ 475.97	$ 4,500.00	$ 475.97	$ 4,500.00	$ 475.97	$ 4,500.00	$ 475.97	$ 4,500.00	$ 475.97	$ 4,500.00	$ 475.97
77	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 462.11	$ 4,500.00	$ 462.11	$ 4,500.00	$ 462.11	$ 4,500.00	$ 462.11	$ 4,500.00	$ 462.11	$ 4,500.00	$ 462.11	$ 4,500.00	$ 462.11	$ 4,500.00	$ 462.11
78	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 448.65	$ 4,500.00	$ 448.65	$ 4,500.00	$ 448.65	$ 4,500.00	$ 448.65	$ 4,500.00	$ 448.65	$ 4,500.00	$ 448.65	$ 4,500.00	$ 448.65	$ 4,500.00	$ 448.65
79	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 435.58	$ 4,500.00	$ 435.58	$ 4,500.00	$ 435.58	$ 4,500.00	$ 435.58	$ 4,500.00	$ 435.58	$ 4,500.00	$ 435.58	$ 4,500.00	$ 435.58	$ 4,500.00	$ 435.58
80	$ 2,500.00	$ -	$ 2,000.00	$ 30,000.00	$ -	$ -	$ 34,500.00	$ 3,242.21	$ 34,500.00	$ 3,242.21	$ 34,500.00	$ 3,242.21	$ 34,500.00	$ 3,242.21	$ 34,500.00	$ 3,242.21	$ 34,500.00	$ 3,242.21	$ 34,500.00	$ 3,242.21	$ 34,500.00	$ 3,242.21
81	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 410.58	$ 4,500.00	$ 410.58	$ 4,500.00	$ 410.58	$ 4,500.00	$ 410.58	$ 4,500.00	$ 410.58	$ 4,500.00	$ 410.58	$ 4,500.00	$ 410.58	$ 4,500.00	$ 410.58
82	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 398.62	$ 4,500.00	$ 398.62	$ 4,500.00	$ 398.62	$ 4,500.00	$ 398.62	$ 4,500.00	$ 398.62	$ 4,500.00	$ 398.62	$ 4,500.00	$ 398.62	$ 4,500.00	$ 398.62
83	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 387.01	$ 4,500.00	$ 387.01	$ 4,500.00	$ 387.01	$ 4,500.00	$ 387.01	$ 4,500.00	$ 387.01	$ 4,500.00	$ 387.01	$ 4,500.00	$ 387.01	$ 4,500.00	$ 387.01
84	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 375.74	$ 4,500.00	$ 375.74	$ 4,500.00	$ 375.74	$ 4,500.00	$ 375.74	$ 4,500.00	$ 375.74	$ 4,500.00	$ 375.74	$ 4,500.00	$ 375.74	$ 4,500.00	$ 375.74
85	$ 2,500.00	$ -	$ 2,000.00	$ 30,000.00	$ -	$ -	$ 34,500.00	$ 2,796.76	$ 34,500.00	$ 2,796.76	$ 34,500.00	$ 2,796.76	$ 34,500.00	$ 2,796.76	$ 34,500.00	$ 2,796.76	$ 34,500.00	$ 2,796.76	$ 34,500.00	$ 2,796.76	$ 34,500.00	$ 2,796.76
86	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 354.17	$ 4,500.00	$ 354.17	$ 4,500.00	$ 354.17	$ 4,500.00	$ 354.17	$ 4,500.00	$ 354.17	$ 4,500.00	$ 354.17	$ 4,500.00	$ 354.17	$ 4,500.00	$ 354.17
87	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 343.85	$ 4,500.00	$ 343.85	$ 4,500.00	$ 343.85	$ 4,500.00	$ 343.85	$ 4,500.00	$ 343.85	$ 4,500.00	$ 343.85	$ 4,500.00	$ 343.85	$ 4,500.00	$ 343.85
88	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 333.84	$ 4,500.00	$ 333.84	$ 4,500.00	$ 333.84	$ 4,500.00	$ 333.84	$ 4,500.00	$ 333.84	$ 4,500.00	$ 333.84	$ 4,500.00	$ 333.84	$ 4,500.00	$ 333.84
89	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 324.12	$ 4,500.00	$ 324.12	$ 4,500.00	$ 324.12	$ 4,500.00	$ 324.12	$ 4,500.00	$ 324.12	$ 4,500.00	$ 324.12	$ 4,500.00	$ 324.12	$ 4,500.00	$ 324.12
90	$ 2,500.00	$ -	$ 2,000.00	$ 30,000.00	$ -	$ -	$ 34,500.00	$ 2,412.51	$ 34,500.00	$ 2,412.51	$ 34,500.00	$ 2,412.51	$ 34,500.00	$ 2,412.51	$ 34,500.00	$ 2,412.51	$ 34,500.00	$ 2,412.51	$ 34,500.00	$ 2,412.51	$ 34,500.00	$ 2,412.51
91	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 305.51	$ 4,500.00	$ 305.51	$ 4,500.00	$ 305.51	$ 4,500.00	$ 305.51	$ 4,500.00	$ 305.51	$ 4,500.00	$ 305.51	$ 4,500.00	$ 305.51	$ 4,500.00	$ 305.51
92	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 296.61	$ 4,500.00	$ 296.61	$ 4,500.00	$ 296.61	$ 4,500.00	$ 296.61	$ 4,500.00	$ 296.61	$ 4,500.00	$ 296.61	$ 4,500.00	$ 296.61	$ 4,500.00	$ 296.61
93	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 287.97	$ 4,500.00	$ 287.97	$ 4,500.00	$ 287.97	$ 4,500.00	$ 287.97	$ 4,500.00	$ 287.97	$ 4,500.00	$ 287.97	$ 4,500.00	$ 287.97	$ 4,500.00	$ 287.97
94	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 279.58	$ 4,500.00	$ 279.58	$ 4,500.00	$ 279.58	$ 4,500.00	$ 279.58	$ 4,500.00	$ 279.58	$ 4,500.00	$ 279.58	$ 4,500.00	$ 279.58	$ 4,500.00	$ 279.58
95	$ 2,500.00	$ -	$ 2,000.00	$ 30,000.00	$ -	$ -	$ 34,500.00	$ 2,081.05	$ 34,500.00	$ 2,081.05	$ 34,500.00	$ 2,081.05	$ 34,500.00	$ 2,081.05	$ 34,500.00	$ 2,081.05	$ 34,500.00	$ 2,081.05	$ 34,500.00	$ 2,081.05	$ 34,500.00	$ 2,081.05
96	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 263.54	$ 4,500.00	$ 263.54	$ 4,500.00	$ 263.54	$ 4,500.00	$ 263.54	$ 4,500.00	$ 263.54	$ 4,500.00	$ 263.54	$ 4,500.00	$ 263.54	$ 4,500.00	$ 263.54
97	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 255.86	$ 4,500.00	$ 255.86	$ 4,500.00	$ 255.86	$ 4,500.00	$ 255.86	$ 4,500.00	$ 255.86	$ 4,500.00	$ 255.86	$ 4,500.00	$ 255.86	$ 4,500.00	$ 255.86
98	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 248.41	$ 4,500.00	$ 248.41	$ 4,500.00	$ 248.41	$ 4,500.00	$ 248.41	$ 4,500.00	$ 248.41	$ 4,500.00	$ 248.41	$ 4,500.00	$ 248.41	$ 4,500.00	$ 248.41
99	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 241.17	$ 4,500.00	$ 241.17	$ 4,500.00	$ 241.17	$ 4,500.00	$ 241.17	$ 4,500.00	$ 241.17	$ 4,500.00	$ 241.17	$ 4,500.00	$ 241.17	$ 4,500.00	$ 241.17
100	$ 2,500.00	$ 8,000.00	$ 2,000.00	$ 30,000.00	$ 200,000.00	$ -	$ 34,500.00	$ 1,795.13	$ 34,500.00	$ 1,795.13	$ 242,500.00	$ 12,617.96	$ 34,500.00	$ 1,795.13	$ 242,500.00	$ 12,617.96	$ 242,500.00	$ 12,617.96	$ 34,500.00	$ 1,795.13	$ 242,500.00	$ 12,617.96
						TOTAL	**Alt #1 Total**	**$ 902,465.99**	**Alt #2 Total**	**$ 902,465.99**	**Alt #3 Total**	**$ 512,469.96**	**Alt #4 Total**	**$ 332,198.29**	**Alt #5 Total**	**$ 512,469.96**	**Alt #6 Total**	**$ 512,469.96**			