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# Operationalization of the CLI-ECA for Stormwater Management: Inherent Challenges and Potential Solutions

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# ACEC (London) – SWM Working Group


## CLI-ECA / ETV and MTDs Consulting Industry Volunteer Review

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# Background Review

- Historically, many municipalities required application of the Particle Size Distribution (PSD) identified in Table 3.3 of the 1994 MOE Stormwater Management Planning and Design Manual.
- In this table, particle sizes less than 20µm (microns) account for 0-20% of the total sample size (by mass)
- Traditional SWMFs (and some LID measures) are supposed to target smaller particle fractions, however data does not appear to support this.

FILE COPY

STORMWATER MANAGEMENT PRACTICES PLANNING AND DESIGN MANUAL

Table 3.3 Particle Size Distribution in Storm Water

| Size Fraction | % of Particle Mass | Average $v_s$ (m/s) ≤ |
|---|---|---|
| ≤ 20 µm | 0 - 20 | 0.00000254 |
| 20 µm ≤ x ≤ 40 µm | 20 - 30 | 0.0000130 |
| 40 µm < x ≤ 60 µm | 30 - 40 | 0.00002540 |
| 60 µm < x ≤ 0.13 mm | 40 - 60 | 0.00012700 |
| 0.13 mm < x ≤ 0.40 mm | 60 - 80 | 0.00059267 |
| 0.40 mm < x ≤ 4.00 mm | 80 - 100 | 0.00550333 |

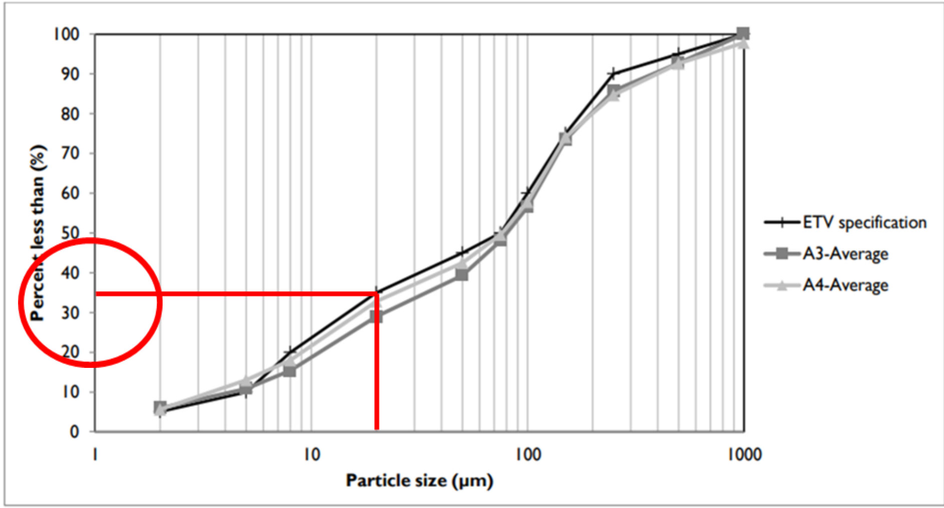
Ontario
Ministry of Environment and Energy

# Background Review

- Extensive research completed by STEP, along with earlier studies completed by SWAMP (2000's)

SWAMP Report "*Performance Assessment of a Flow Balancing and Wetland Treatment System - Toronto, Ontario" (2005)*

- "*the system was effective in removing all particle sizes greater than 30 µm*" (S.4.4.5)
- "*...even with larger permanent pools and longer settling times, it is not practical to expect reductions beyond a median effluent particle size of 20 µm.*"

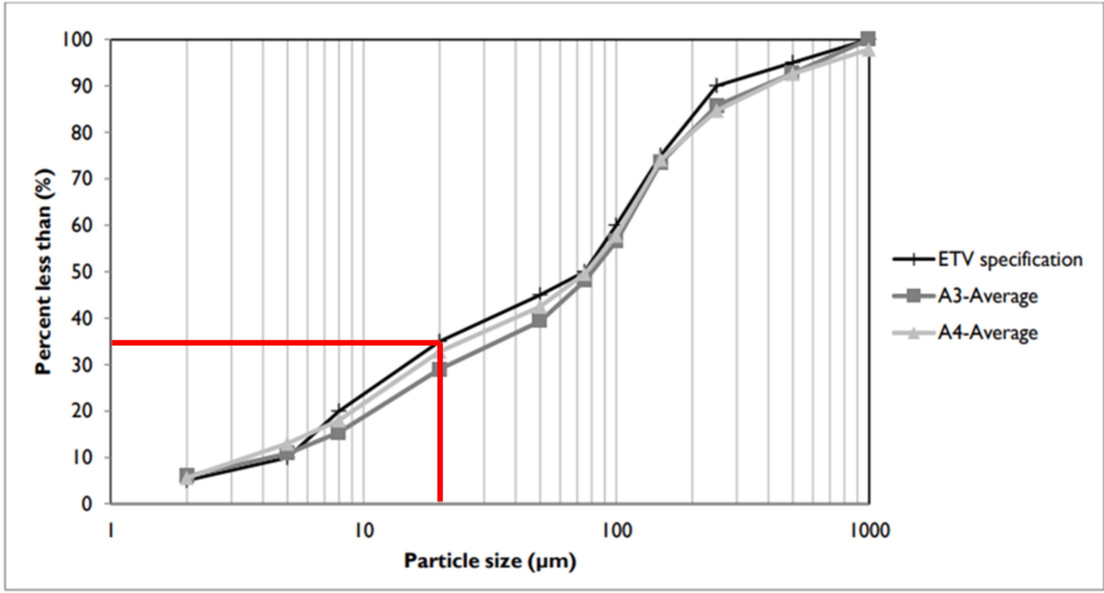



# Comparison to ETV PSD

- The Environmental Technology Verification (ETV) Program utilizes a PSD which includes sub-20µm particles which account for approximately 35% of the total sample (by mass). Represents a 1.5X enrichment of extremely fine particles.

- The ETV PSD is very similar to the sediment PSD specified by the New Jersey lab protocol (NJDEP)

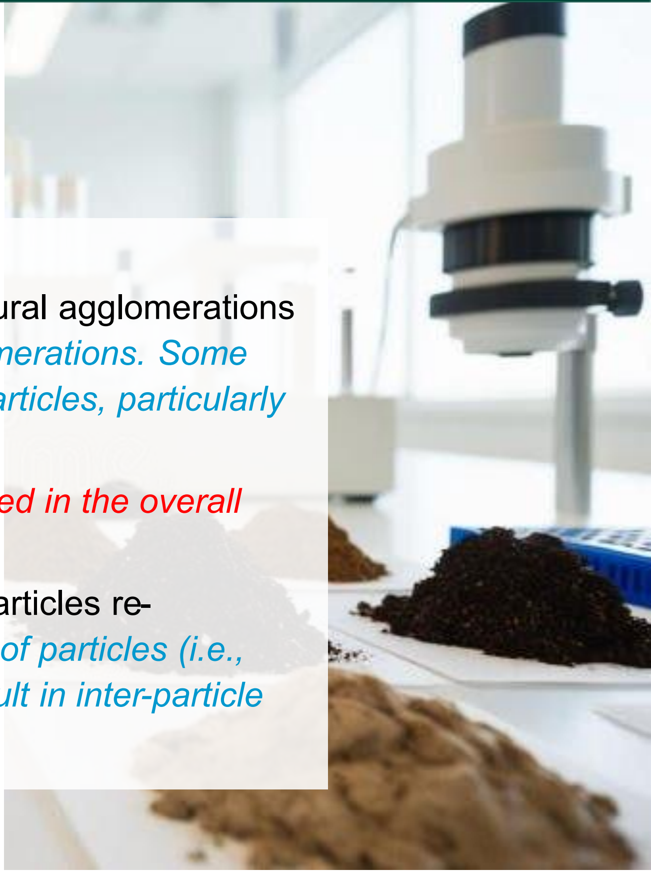
- Current MECP CLI-ECA requires use of the ETV protocol & PSD for design (sizing) of Sedimentation Manufactured Treatment Devices (S-MTDs)




# PSD Methodological Concerns

**A. Ontario MOE/MECP Sample Preparation Procedure**
for PSD Testing (applicable to the SWAMP studies):

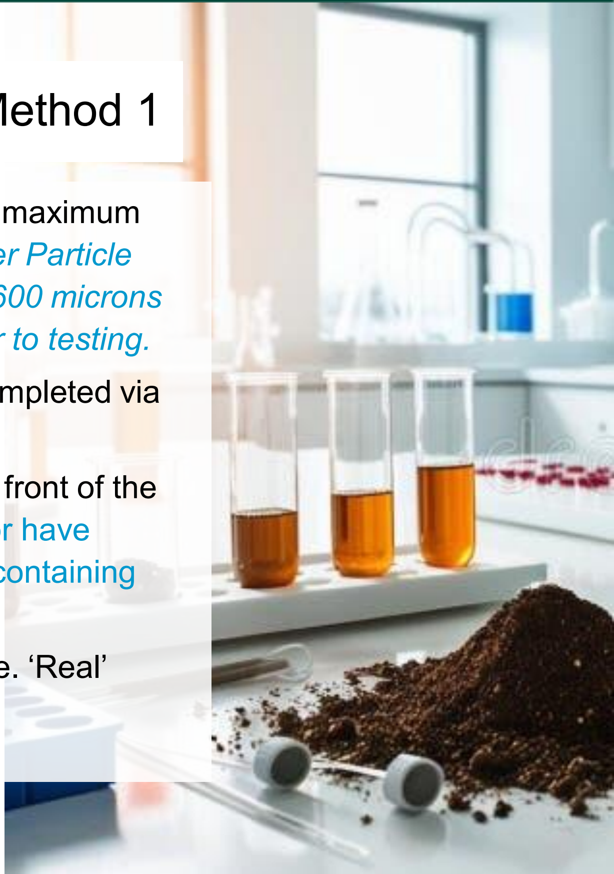
- Water samples containing sediment collected by means of autosampler.
- Samples dried and artificially decimated into constituent components (natural agglomerations destroyed). *Introduces inaccuracy in the form of pulverizing natural agglomerations. Some larger particles run the risk of being pulverized into two or more smaller particles, particularly if a mortar and pestle or similar tool is used in the preparation process.*
- Particles larger than 2mm (sand) were then sieved out. *These are excluded in the overall PSD analysis.*
- Calgon (sodium hexametaphosphate) addition prior to testing (prevents particles re-flocculating in suspension). *Especially problematic for the finest fractions of particles (i.e., clays and some silts), which have cation exchange sites and normally result in inter-particle bonding but are instead coated with the Calgon.*



# PSD Methodological Concerns

## B. **2012 STEP Parking Lot Study (**ISO 13320:2009) – Method 1

- Per Swiss ISO Institute, method requires samples be pre-sieved according to the maximum size range a laser detector can measure. *STEP study notes that a Coulter Counter Particle Size Analyzer was used. The laser counter has an upper particle size range of 1600 microns (1.6mm). Therefore, coarser material would be pre-sieved out of the sample prior to testing.*
- Test method also requires particle dispersion be completed. Dispersion can be completed via sonification, which vibrationally decimates aggregate particles.
- Testing method notes aerosolization of particles in droplets of water (for testing in front of the laser). "Significant error" possible if droplets are small and evaporate during test or have differential settling velocities as a result of drag forces. Further, aerosol droplets containing sediment have different refractive index, which can bias the results.
- Theory underpinning the testing protocol assumes particles are spherical in nature. 'Real' particles in solution behave differently than theoretical reference solution.



# PSD Methodological Concerns

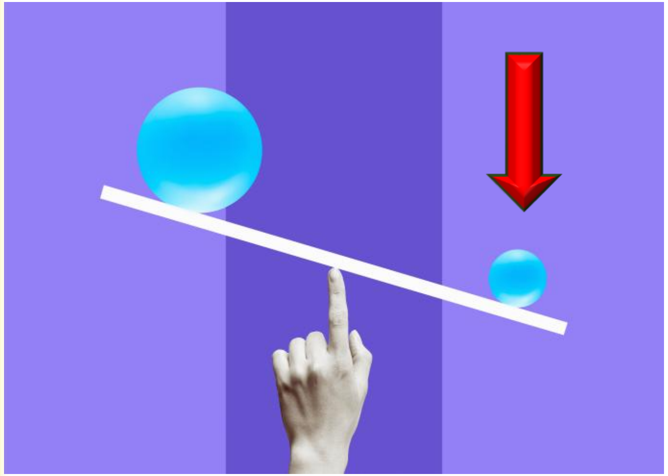
## C. **2012 STEP Parking Lot Study (BSG 3406-4)** – Method 2

- BS 3406-4 provides guidance on sample preparation for particle size determination using microscopy and image analysis. Emphasis on the need "*to disperse samples into primary particles*" while considering their behavior in the intended application, the specific challenges of the material, and the chosen analytical method.
- Sample preparation method covers the preparation of both dry and wet samples, ensuring complete wetting of particles and appropriate dispersion to prevent clumping or aggregation that would lead to inaccurate results.
- The British Standards Website notes BSG 3406-4 provides a method for "using microscopes to measure the size of particles in the range from 2 nm to 1 mm". *Focus is on small particles and hence anything bigger than a fine sand is removed.*
- Relatedly, sample preparation requires samples be "dried and sieved" prior to having a dispersing agent added. *Presumably the sieving process is when particles larger than 1mm in diameter would be removed*

# PSD Methodological Concerns

**Summary Concerns and Critiques of MECP and STEP PSD Methodologies:**

**Conclusion 1 -** these approaches significantly skew the results with a strong bias towards much finer particulate matter (< 20 um) by % mass in the overall PSD range than occurs in the typical urban environment.



# PSD Targets Assessment – Further Considerations

**Conclusion 2 –**

At best, unclear whether sub-20um particles represent a significant proportion by % vol. or mass or are appropriate target particles size due to methodological PSD biases and subwatershed rating.

At worst, sub-20um particles represent only fraction of a fraction by total volume entering the watercourse from development area that may be practically treated.

This <u>must</u> be considered in conjunction with costs to be borne by publicly funded entities.

# Practical Implications

- Previous Capital Cost Review Case Study Examples from London, Ontario:
  - Western Road / Philip Aziz
  - Col. Talbot Road
  - Liberty Crossing (Greenfield Subdivision)
- Average 5X to 10X Capital Cost for comparative ETV design sizing prior to ongoing operational costs for Municipality.

# O&M Costs Projections – Case Study Western Rd./ Philip Aziz

10yr Operational and Maintenance Cost Projection for Case Study Example #1 - Western Road / Philip Aziz (~36 ha site)

Baseline O&M Cost for MOE 1994 PSD design sizing (70% TSS Removal Required):

- S-MTD Model PSMU5653_10.
- Total Sump Vol. ~ 20m$^3$ / 0.914m Max. Sediment Depth.
- Estimated 1.5yrs Cleanout frequency under normal loading conditions.
- $23K Budget Cost per cleanout excluding any ROW closure costs (TMP) if applicable.
- EMC=70 mg/L

# O&M Cost Projections – Case Study Western Rd./ Philip Aziz

| Target TSSR | PSD Case | Treatment Type - Unit Model (EMC 70 mg/L) | Est. Budget Capital Cost | Est. 10-Year Maintenance Cost | Total 10-Year Ownership Cost | Cost Increase |
|---|---|---|---|---|---|---|
| 70% | 1994 MOE (Fine) | HDS - (1) PMSU 5653_10 Offline w/ Diversion vault | $177,000 | $181,000 | $358,000 | - |
| 50% | ETV | HDS - (2) CDS_12 w/ 1x Parallel Diversion Structure | $429,000 | $256,000 | $685,000 | 1.9 X |
| 80% | ETV | Filter – SF CIP Vault / 304 Cartridges, System treatment flow rating 300 L/s | $1,383,000 | ($489,000) – $1,461,000 | (1,872,000) – $2,844,000 | (5.2 X) - 7.9 X |
| 80% | ETV | HDS - (1) CDS_12 W/ diversion vault. | $278,000 | $233,000 | (1,278,000) – $1,639,100 | (3.6 X) – 4.6 X |
| | | Filter - Twin SF-0820 Vaults / 91 Cartridges, System treatment flow rating 91 L/s | $579,000 | (188,000) – $549,000 | | |

# O&M Cost Projections – Case Study Western Rd./ Philip Aziz

**Maintenance Cost Estimate Notes:**

1. Capital cost does not include any labour for contractor installation / CIP works.
2. For Filter Units - includes new cartridge supply and return of old cartridge casings to supplier over 10 yr period. Assuming minimum 30% filter replacement cost for damage over lifespan.
3. All 10-year maintenance Costs based on 2.5% CPI
4. Includes diversion & junction maintenance hole structures
5. Design Based on Event Mean Concentration (EMC) = **70 mg/l**
   (Costs) - Highly maintained drainage area; frequent street sweeping to reduce sediment loading, with est. 3-year maintenance period vs min. annual maintenance for higher sediment loading.
6. For filter operation, assumes full hydraulic drop available. Critical design parameter for filter function is not always achievable due to topographic constraints on flatter sites or with tailwater.

Factoring in reasonable construction cost multiplier of 1.5X Capital Cost, and a more conservative **EMC of 150 mg/L** – results in a larger change in the overall 10-year installed cost increase especially where filtration technology is used (mass and flow-based design approach).

# O&M Cost Projections – Case Study Western Rd./ Philip Aziz

| Target TSSR | PSD Case | Treatment Type - Unit Model (EMC 150 mg/L) | Est. Budget Capital Cost Installed (1.5X) | Est. 10-Year Maintenance Cost | Total 10-Year Installed Ownership Cost | Installed Cost Increase |
|---|---|---|---|---|---|---|
| 70% | 1994 MOE (Fine) | HDS - (1) PMSU 5653_10 Offline w/ Diversion vault | $265,200 | $258,000 | $523,500 | - |
| 50% | ETV | | | | | 2.0 X |
| 80% | ETV | | | | | (9.5 X) - 12.2 X |
| 80% | ETV | | | | | (6.1 X) - 7.4 X |

**True Installed & Maintenance Costs Still Need to Account For:**

- Additional footprint for installation of large filter systems and diversion structures not strictly accounted for, impacts relocation of adjacent works (primarily in retrofit projects).
- Utilities congestion is major unseen factor. Practical installation limitations that could dramatically push up costs (relocation, potential land cost for expropriate/easements etc.)
- More frequent and longer duration road closures times for maintenance (with confined space entry) for all filter systems, estimated to be several times vac-truck for typical S-MTD units. Increased municipal staff time.

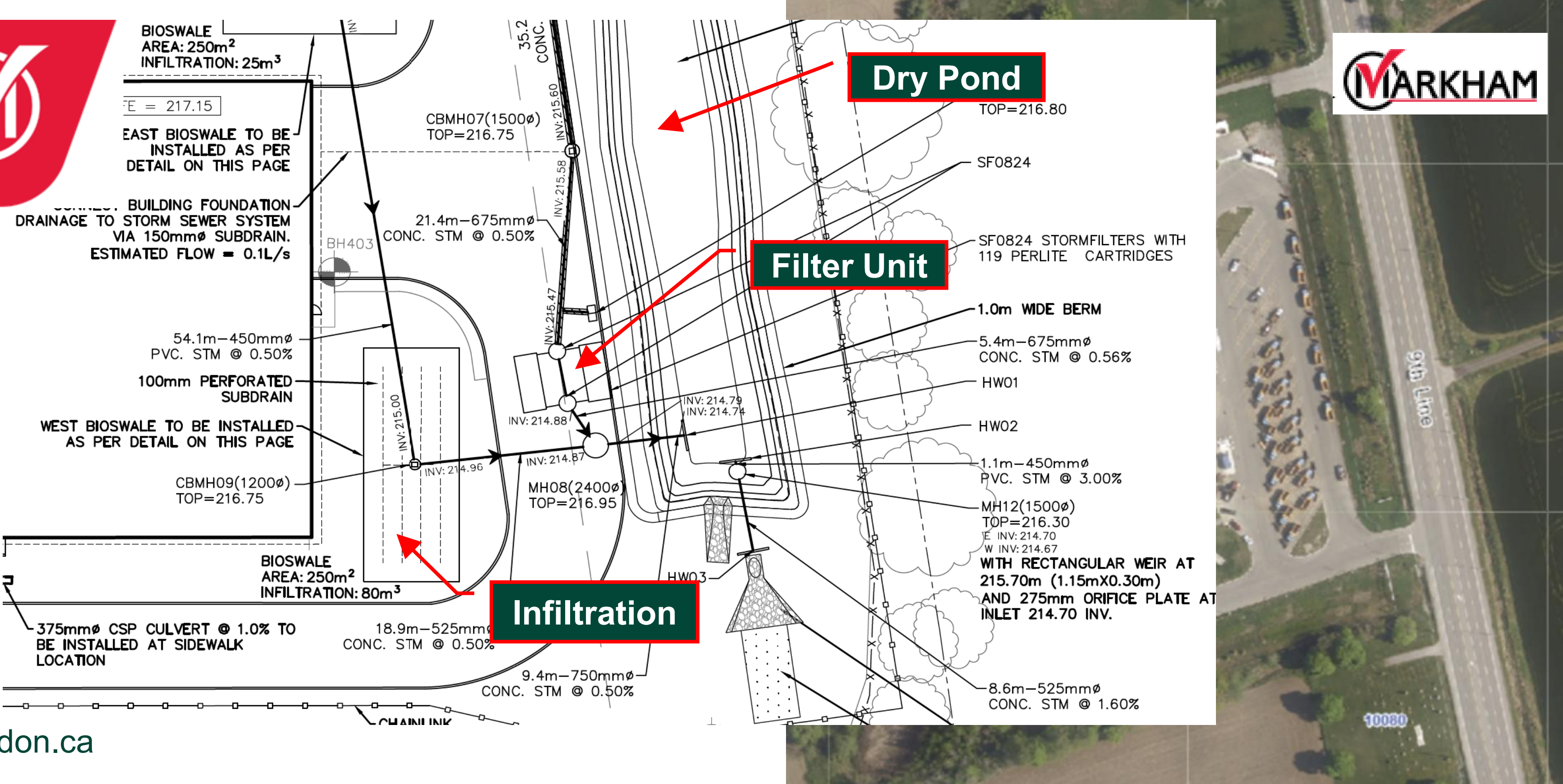
# City of Markham – Pilot Filter Project

**Markham East Work Yard – City's First Filter System**

**Robert Muir, M.A.Sc., P.Eng**. Manager, Stormwater, City of Markham


- Small site in Rouge River Watershed
- SWM strategy included infiltration galleries for roof runoff and filters and a dry pond for surface runoff
- Filter catchment area = 2.25 ha
- Constructed in 2021
- Inspected in 2022 and 2023
- Cleaned in 2024

# City of Markham – Pilot Filter Project

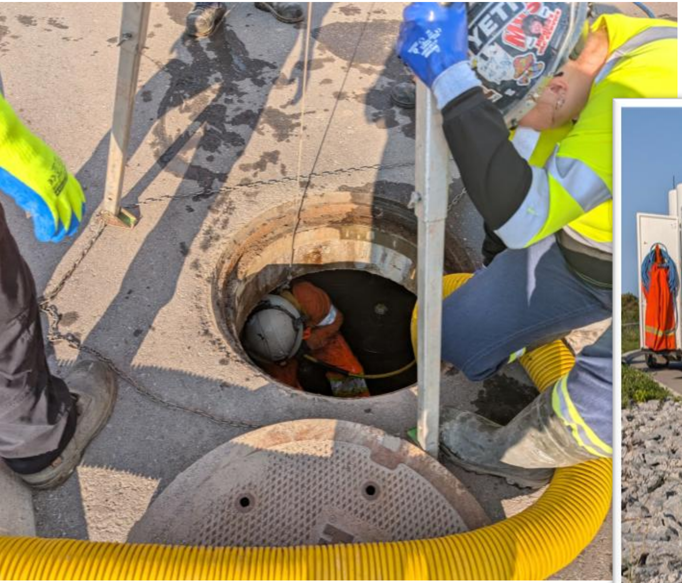


# City of Markham – Pilot Filter Project

## Markham East Work Yard – Filter Cartridges (Old and New)

# City of Markham – Pilot Filter Project

## Markham East Work Yard – Filter Removal & Cleaning




# City of Markham – Pilot Filter Project

## Markham East Work Yard – O&M Costs

| Facility | Catchment (ha) | Year Assumed | Year Cleaned | Service Life (years) | Sediment Removal Cost | Cost / ha / yr |
|---|---|---|---|---|---|---|
| Filter (East Yard) | 2.25 | 2021 | 2024 | 3 | $44,341 | $6,500 |
| Wet Pond ID 60 | 240 | 2002 | 2025 | 23 | $1,329,000 | $241 |
| Wet Pond ID 55 | 15.6 | 2006 | 2025 | 19 | $140,605 | $474 |

- The Markham East Yard filter cartridge replacement cost $44,000, equivalent to $44k / 2.25 ha over 3 years = approx. **$6500/ha/yr**
- This equates to between 14X and 27X maintenance cost increase compared to wet-pond SWMFs

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# Practical Conclusions

- Significant additional costs (5X – 12X) to treat urban stormwater to an Enhanced (80%) level using ETV protocol (removal of sub-20um particles) comparing different types of MTDs.  This further escalates (14X - 26X) when Filters (ETV) are compared to traditional wet-pond SWMFs.

- The implicit ETV requirement for removal of sub-10um particles borders on potable water treatment thresholds and is not a sustainable target for stormwater management at **ANY** applicable scale in our opinion.

- Cost-effective operation and maintenance is key to continued function of all SWM measures.  No other SWM types are required to meet ETV protocol in design or outcomes.  A more balanced design approach should be permitted by the MECP (CLI-ECA).

- Setting unrealistic and cost-prohibitive targets could inhibit implementation of BMP treatment approaches. Potentially to negatively impact water quality as less desirable approaches may be adopted to circumvent onerous requirements.

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# Proposed Solutions (CLI-ECA)

- Use of **Best Available Treatment Economically Achievable** (BATEA) principle in design should be central to SWM quality treatment target requirements.

- Use of 1994 MOE PSD is recommended for S-MTD's and consistent with all other SWM measures where PSD is implicit in design / sizing.

- Operation and Maintenance (frequency/cost for cleanout etc.) must be clear, affordable, practical and key to any design proposals; a non-maintained system is a non-functioning system.

- Use of ETV for <u>design</u> and implementation of filters is impractical / unfeasible for full-scale adoption across urban infrastructure. This is not consistent with requirements other SWMF infrastructure (e.g wet-ponds and LID measures). Use of filter systems should be extremely selective (i.e. only highly sensitive 1$^{st}$ order cold-water receivers) with pretreatment measures to assist longevity.

- SWM (sedimentation) treatment measures including at-source **inlet pre-treatment** should be given credit and a simple treatment-train approach should also give (reduced) credit for redundancy for in-line systems.

# End – Thank You

# Questions?