Field Performance Evaluation of a New Stormwater Pre-Treatment System in Cold Climates

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Engineering Resilience – Innovations in Stormwater and Forecasting

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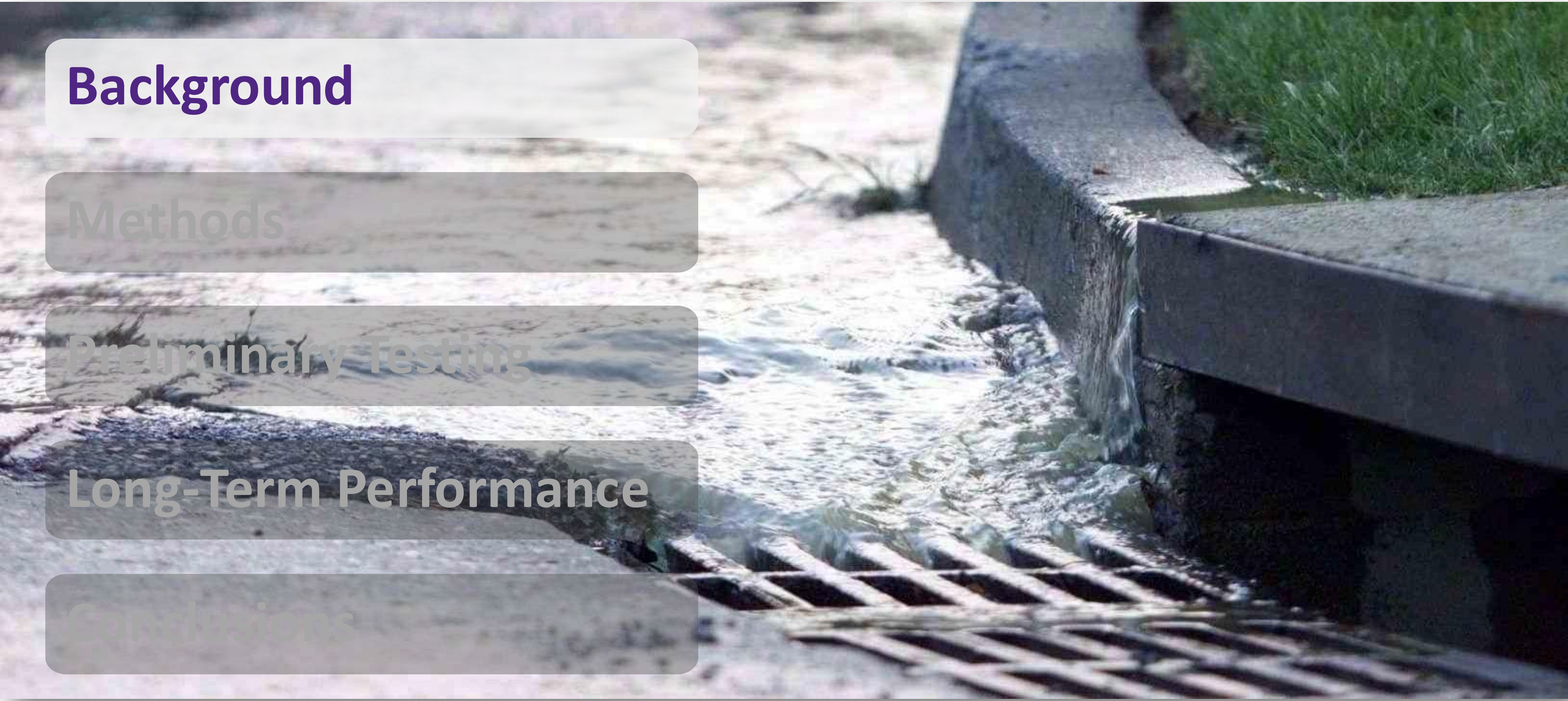
Background

Methods

Preliminary Testing

Long-Term Performance

Conclusions



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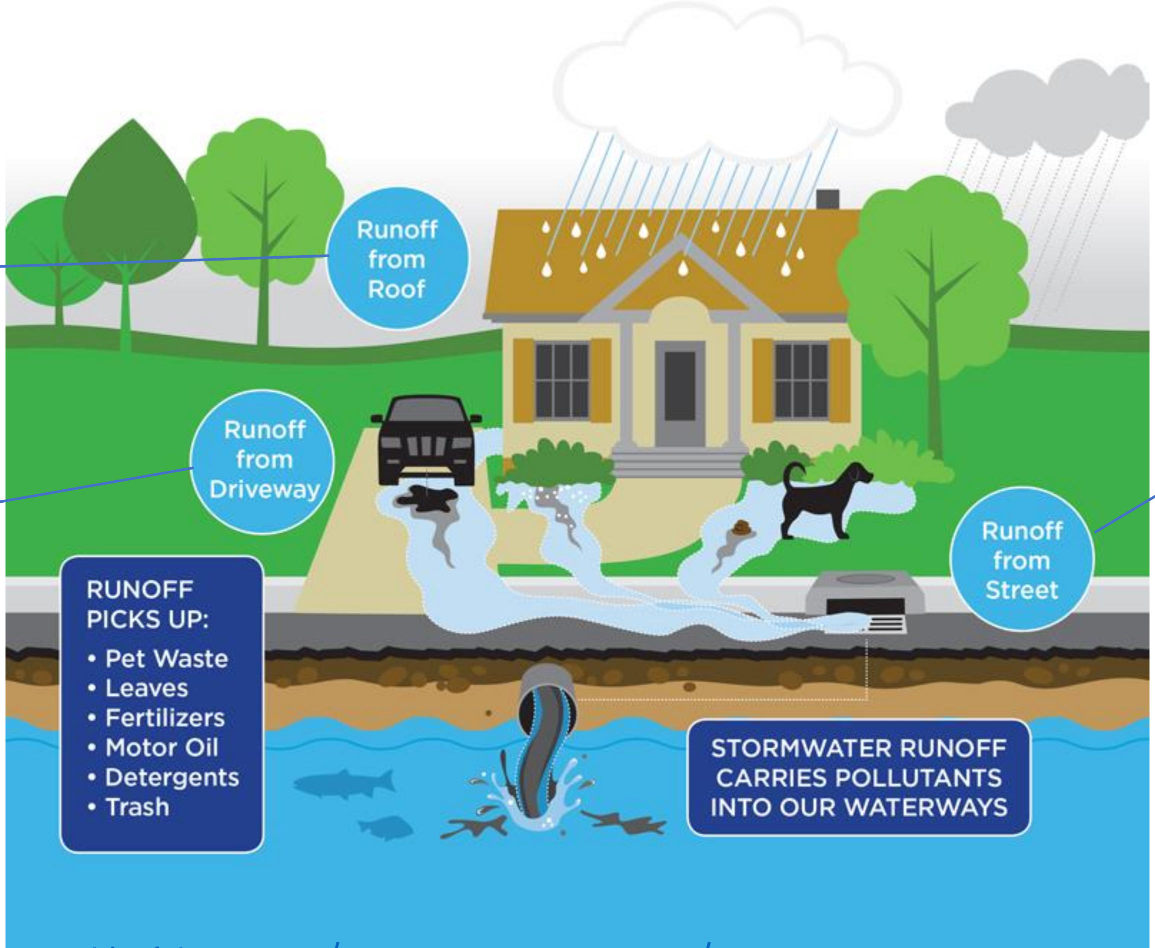
Stormwater Management



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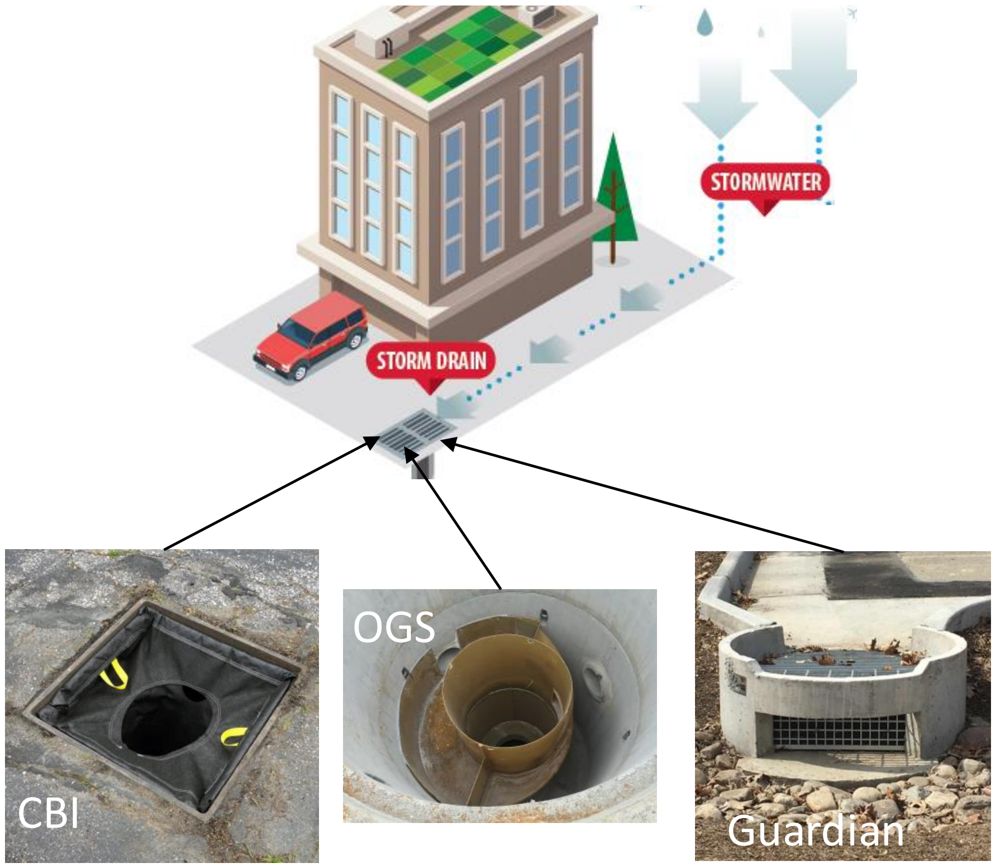
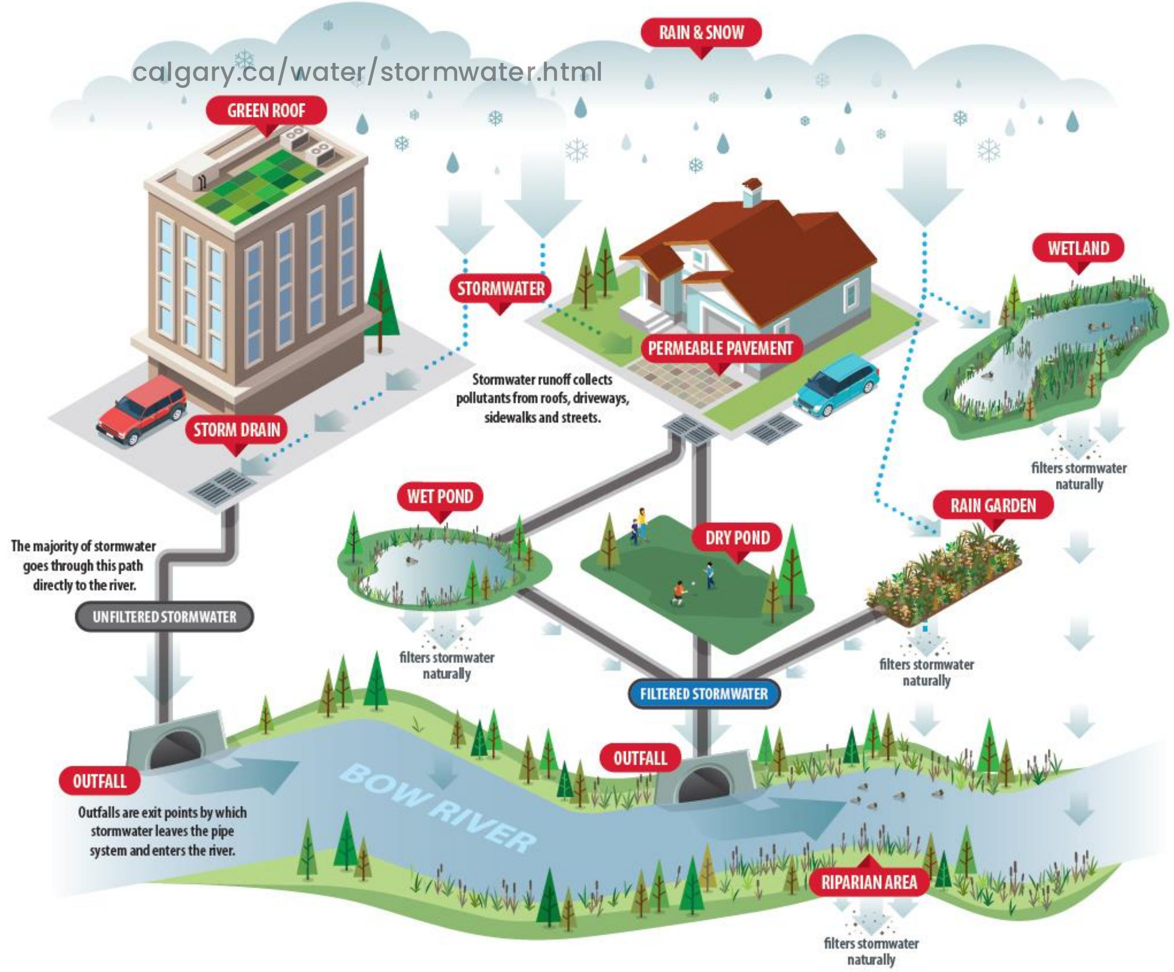
Background

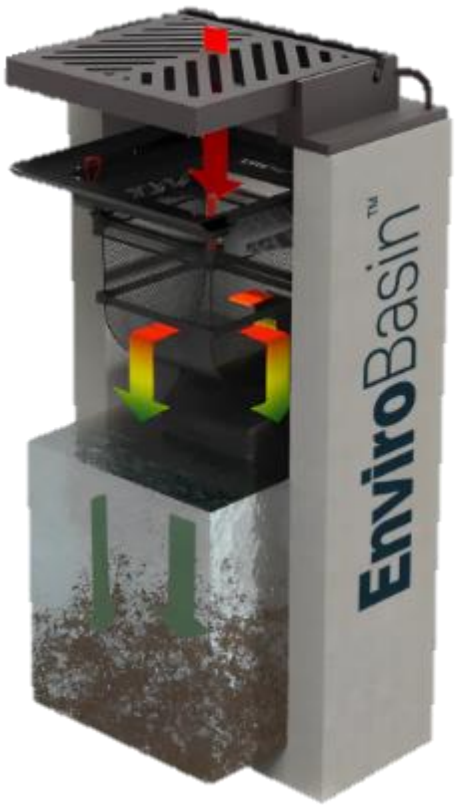
Pre-treatment Devices





Background

The EnviroBasin



Background

The EnviroBasin

https://youtu.be/ZKlC6o0PmCc?si=OJNSl6o90pjr0X06

Background

Research Gaps

- Studies related to pre-treatment devices (CBIs, OGSs etc.) focus on *laboratory or field testing, not both* (e.g., Morgan et al., 2005b; Obispo & Maclure, 2009; Remley et al., 2005)
- *EnviroBasin has not been rigorously tested* in northern climate, for laboratory testing guidelines or field conditions (e.g., Wiebe, 2021; Houle et al., 2020; Wilson et al., 2009; EnviroPod, 2024)
- Most field studies evaluating pre-treatment devices focus on *daily sediment capture rates rather than total suspended solid removal (TSS) efficiency* or sediment particle size distribution (PSD) (e.g., Kostarelos et al., 2011b; Smith et al., 2020)
- Field studies often use *limited analytical methods* that are not able to fully capture performance of pre-treatment device (e.g., Schaffer et al., 2023; Ackerman et al., 2011; Lee et al., 2002)

Background

Project Objectives

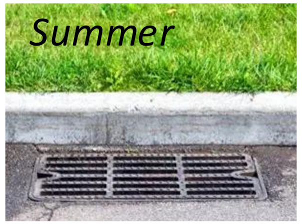
- **Preliminary Testing**
  Evaluate the effectiveness of the EnviroBasin in removing suspended solids from urban runoff via a combination of laboratory and field tests

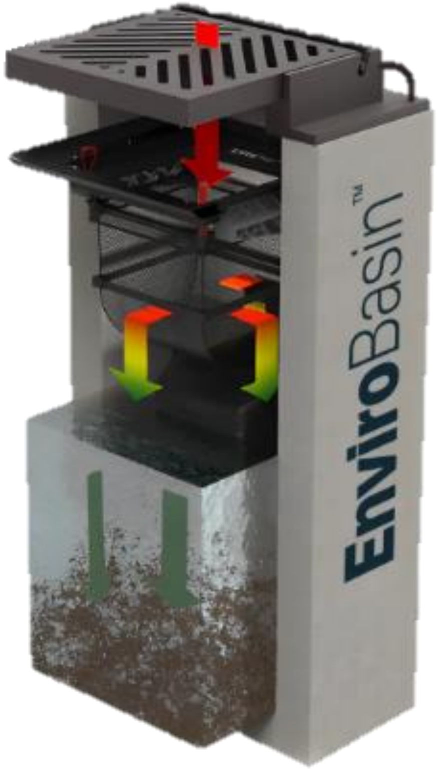
Laboratory Tests

Synthetic Events

Natural Events

- **Long-Term Performance**
  Investigate the performance of the EnviroBasin in removing sediment and other stormwater contaminants across variable seasons in a cold climate





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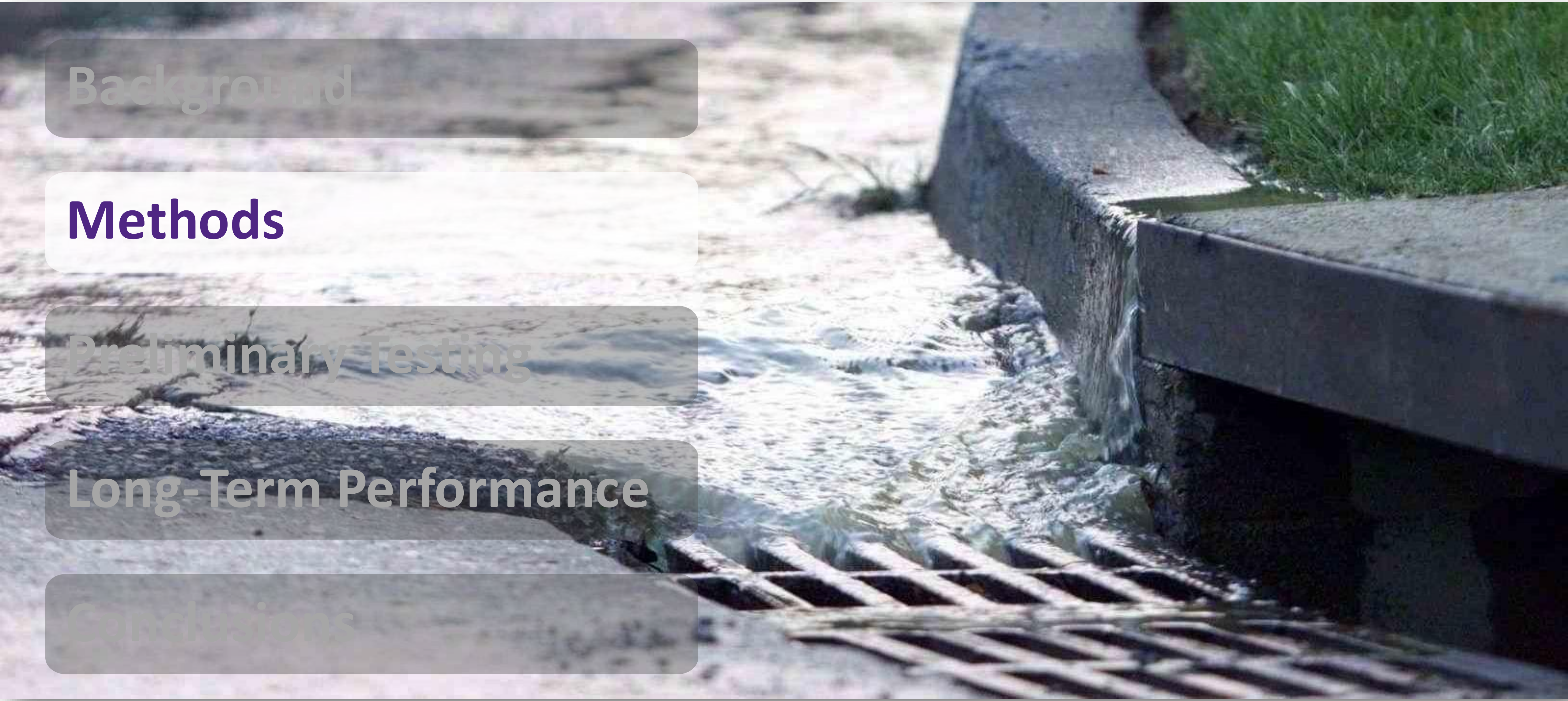

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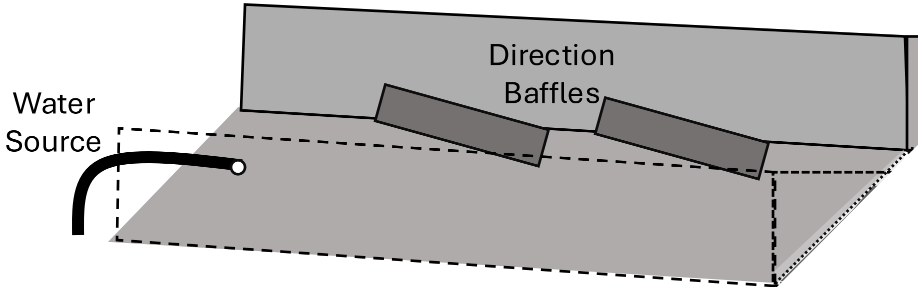
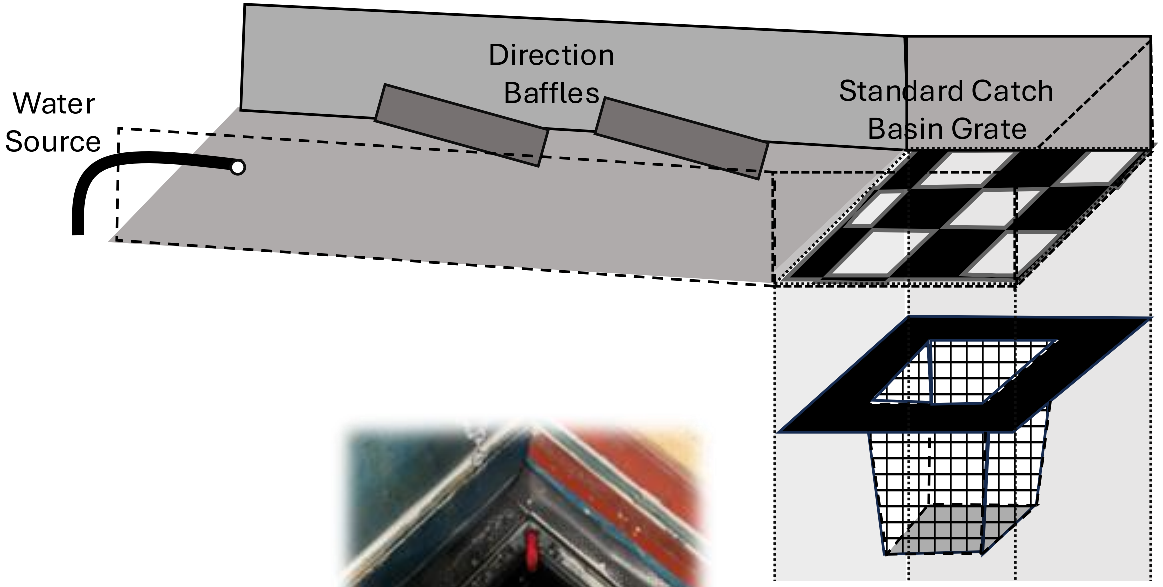
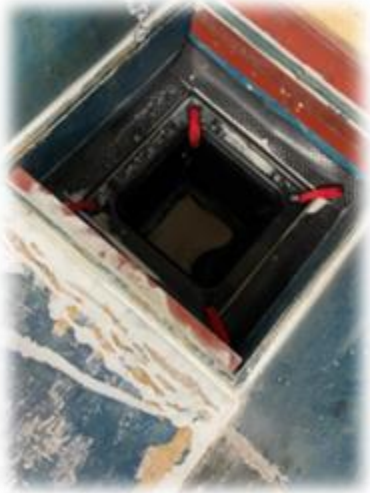
Methods: Laboratory Testing



Methods: Laboratory Testing





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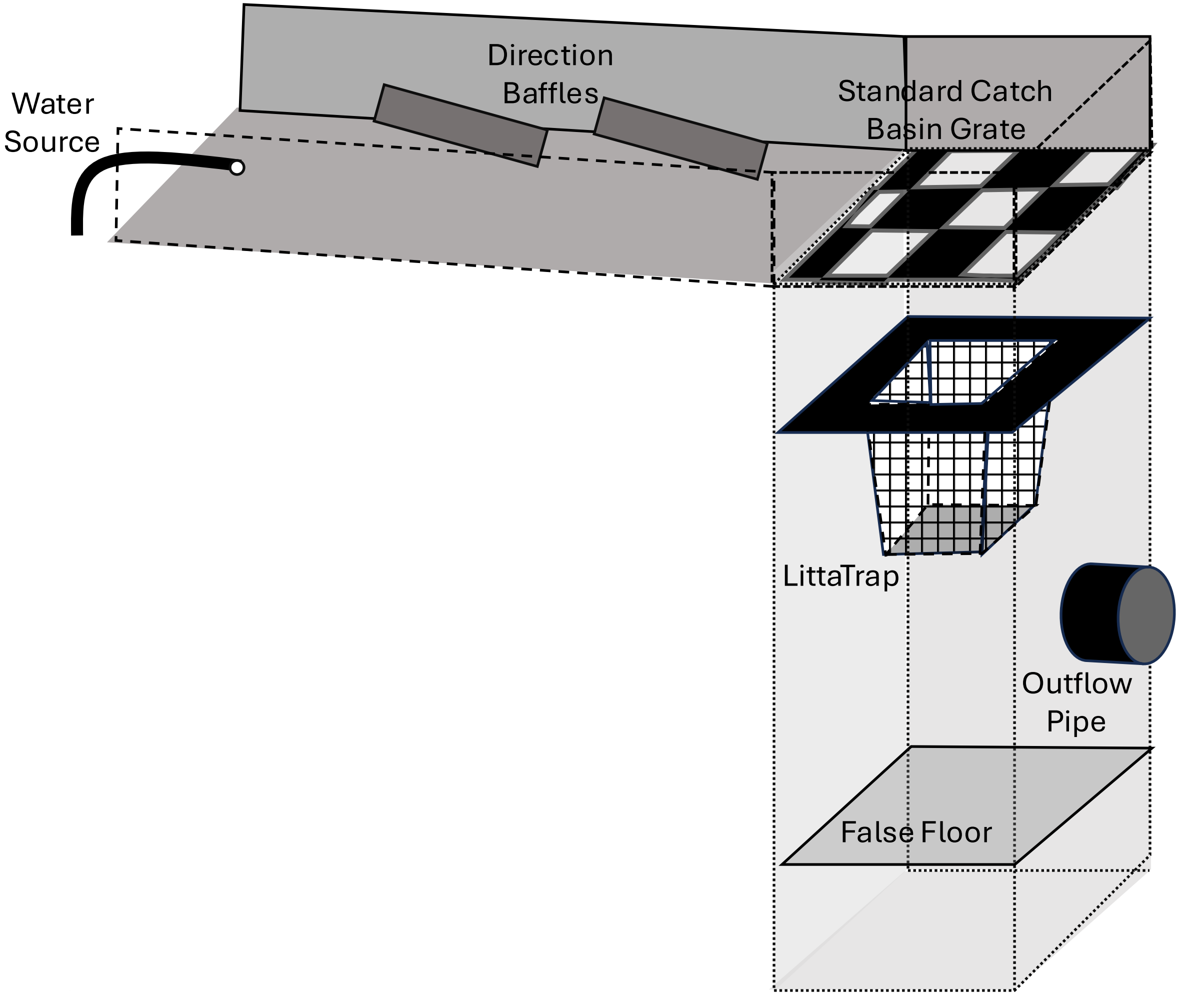
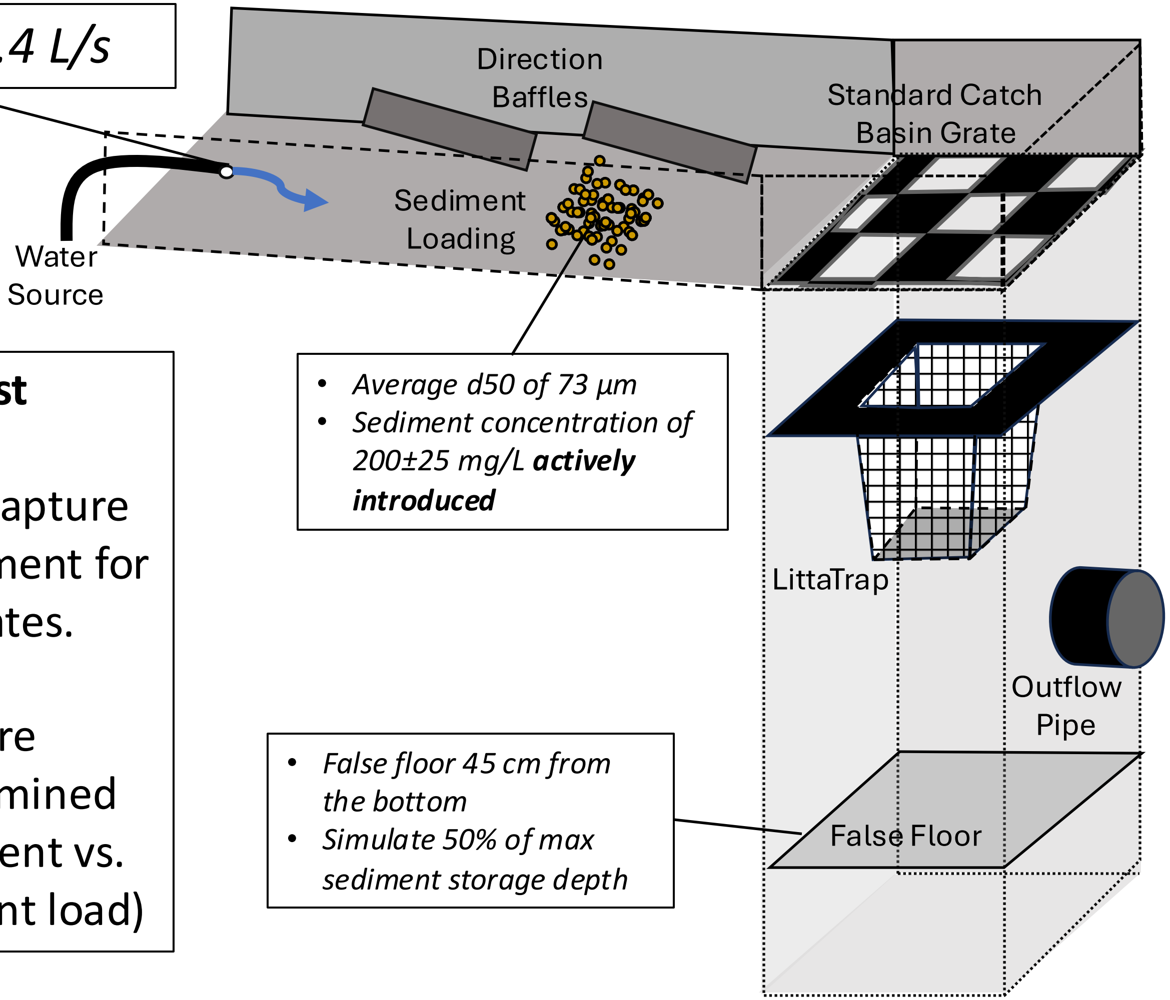
Methods: Laboratory Testing



Methods: Laboratory Testing

- *0.24 up to 8.4 L/s*



- *Average d50 of 73 μm*
- *Sediment concentration of 200±25 mg/L **actively introduced***

- *False floor 45 cm from the bottom*
- *Simulate 50% of max sediment storage depth*

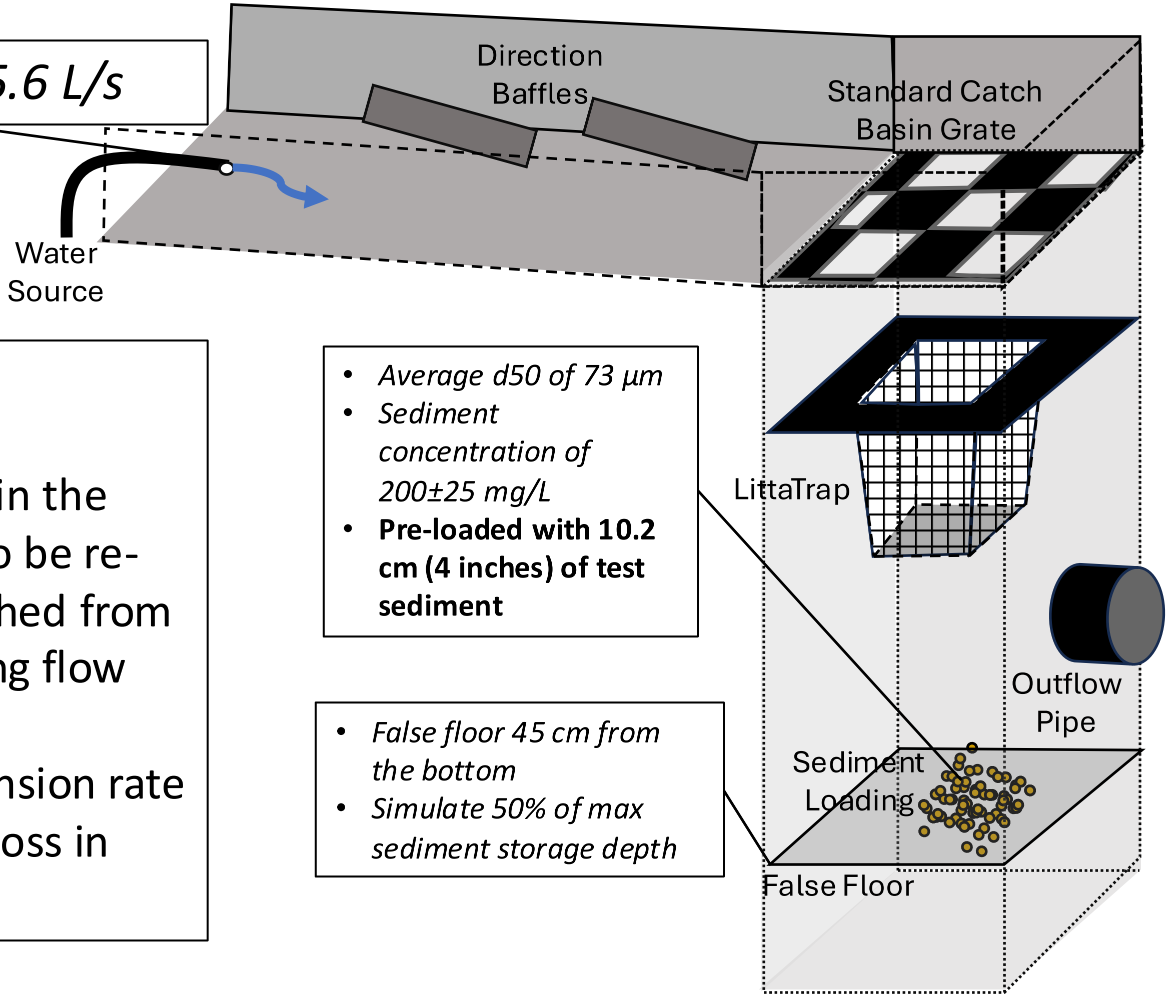
Capture Test

- Assess ability of EnviroBasin to capture and retain sediment for different flow rates.
- Sediment capture efficiency determined (retained sediment vs. influent sediment load)

- ***PSD**, Removal Efficiency*
- *Measure mass and PSD of injected and retained sediment*

Methods: Laboratory Testing

- *1.2 up to 15.6 L/s*



Scour Test

- Assess potential for sediment captured in the EnviroBasin sump to be re-suspended and flushed from system under varying flow rates.
- Measured re-suspension rate (SSC and sediment loss in effluent).

- *Average d50 of 73 μm*
- *Sediment concentration of 200±25 mg/L*
- **Pre-loaded with 10.2 cm (4 inches) of test sediment**

- *False floor 45 cm from the bottom*
- *Simulate 50% of max sediment storage depth*

- *Analyzed for **SSC** and PSD (adjusted for background concentration).*

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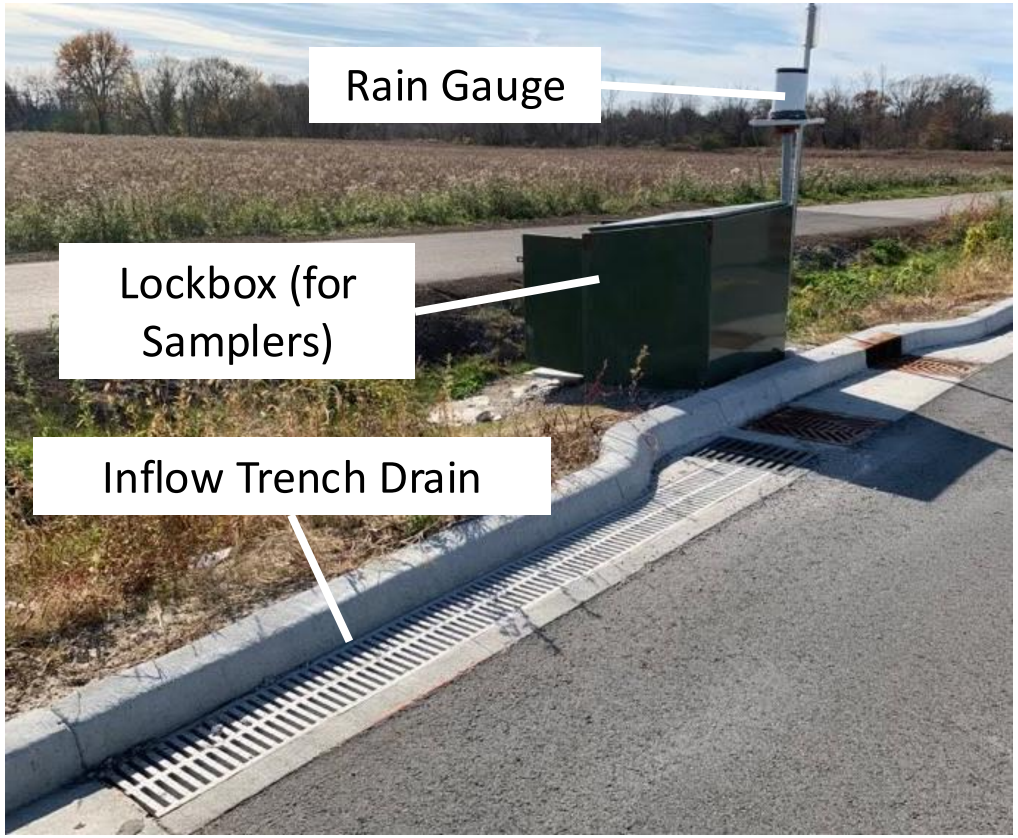
Methods: Field Testing

Methods: Field Testing



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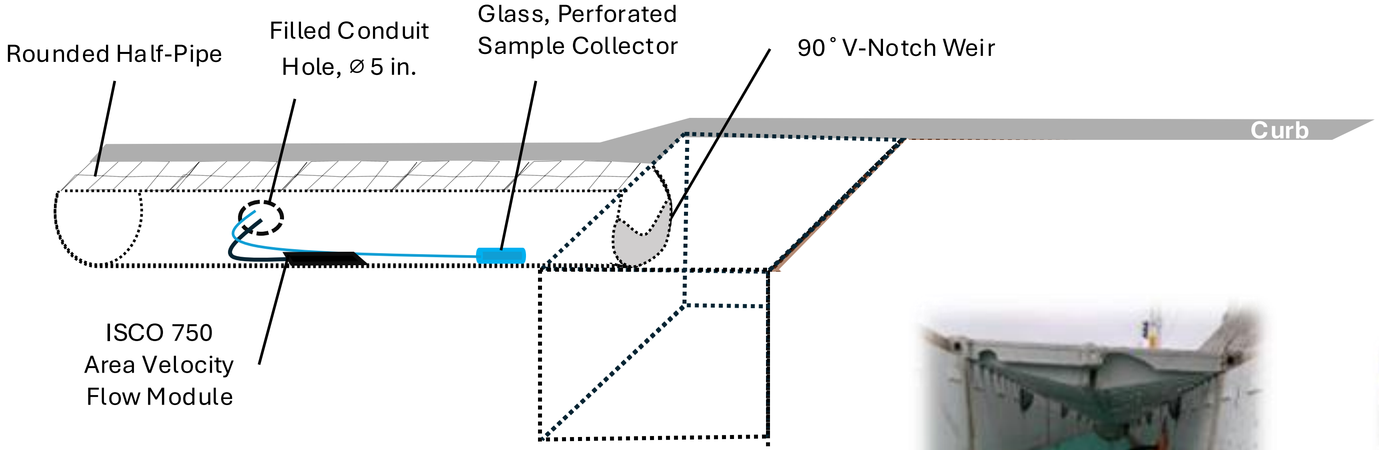
Methods: Field Testing



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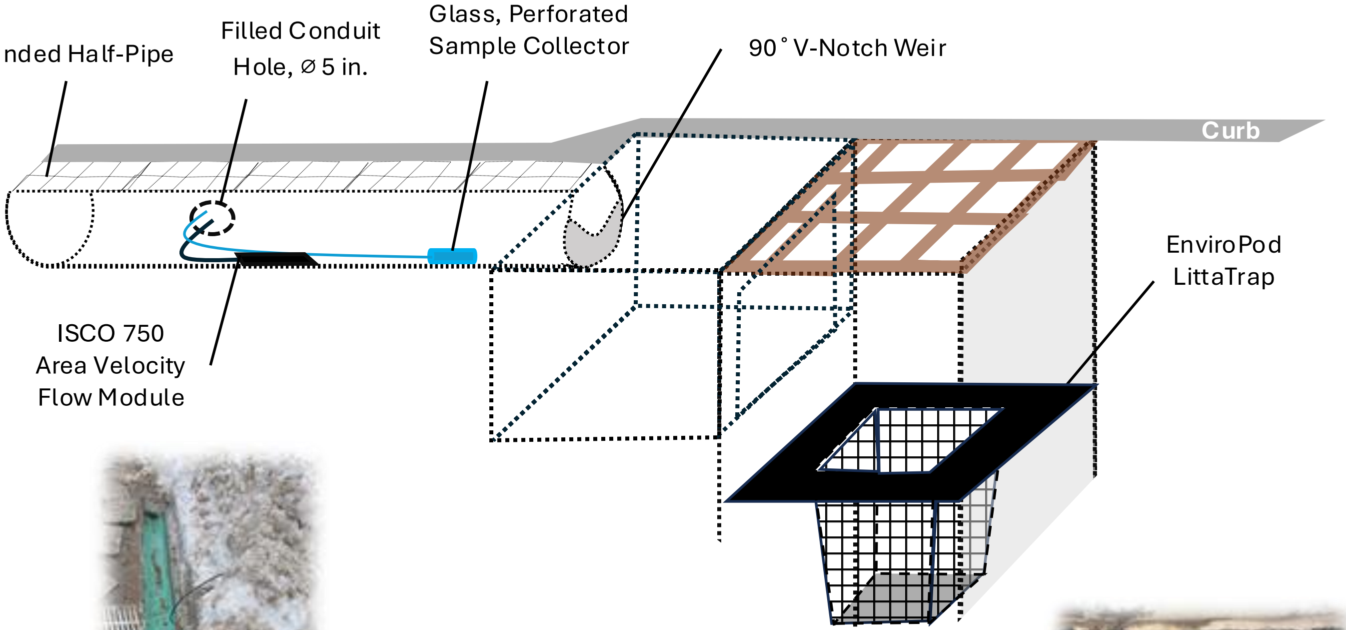

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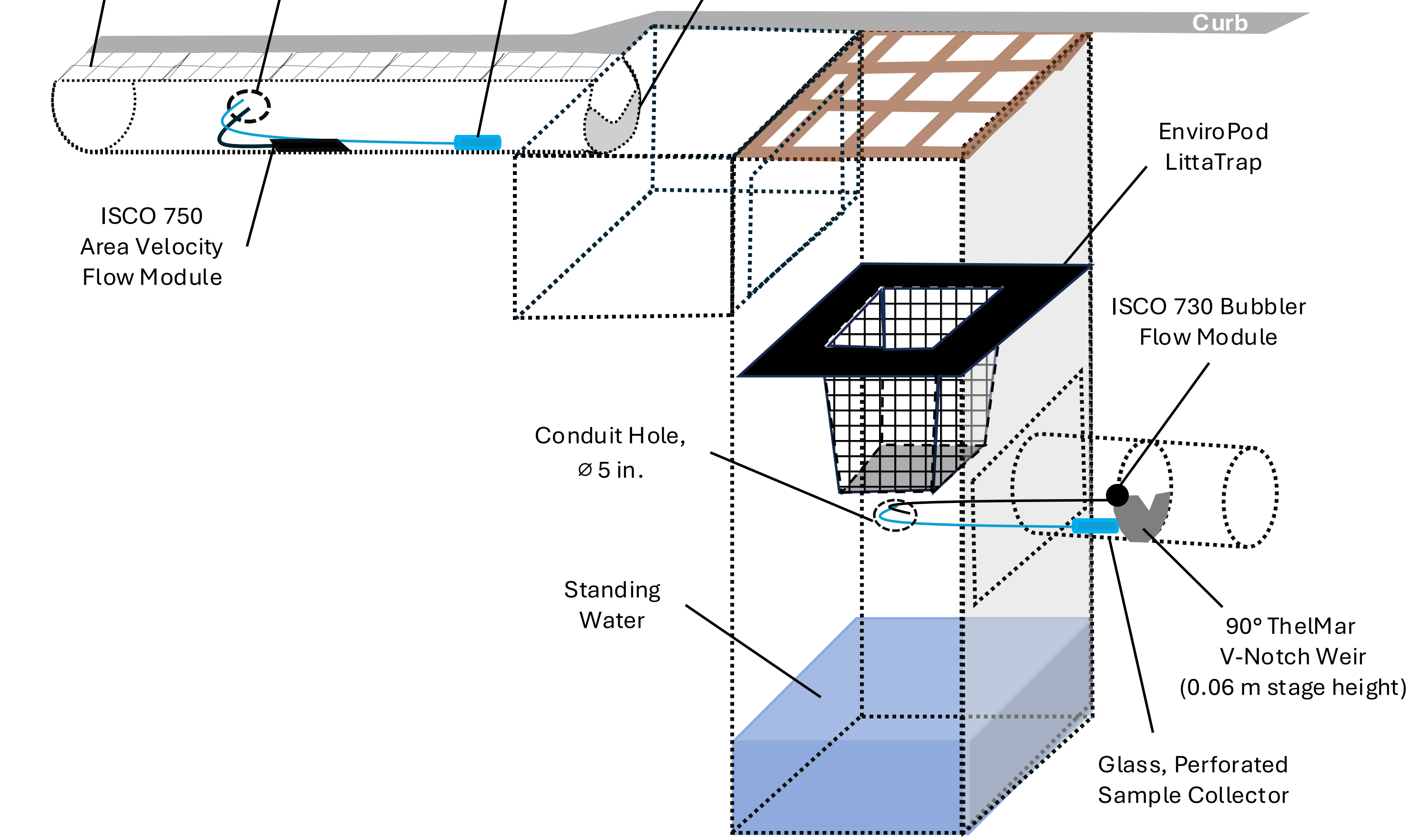

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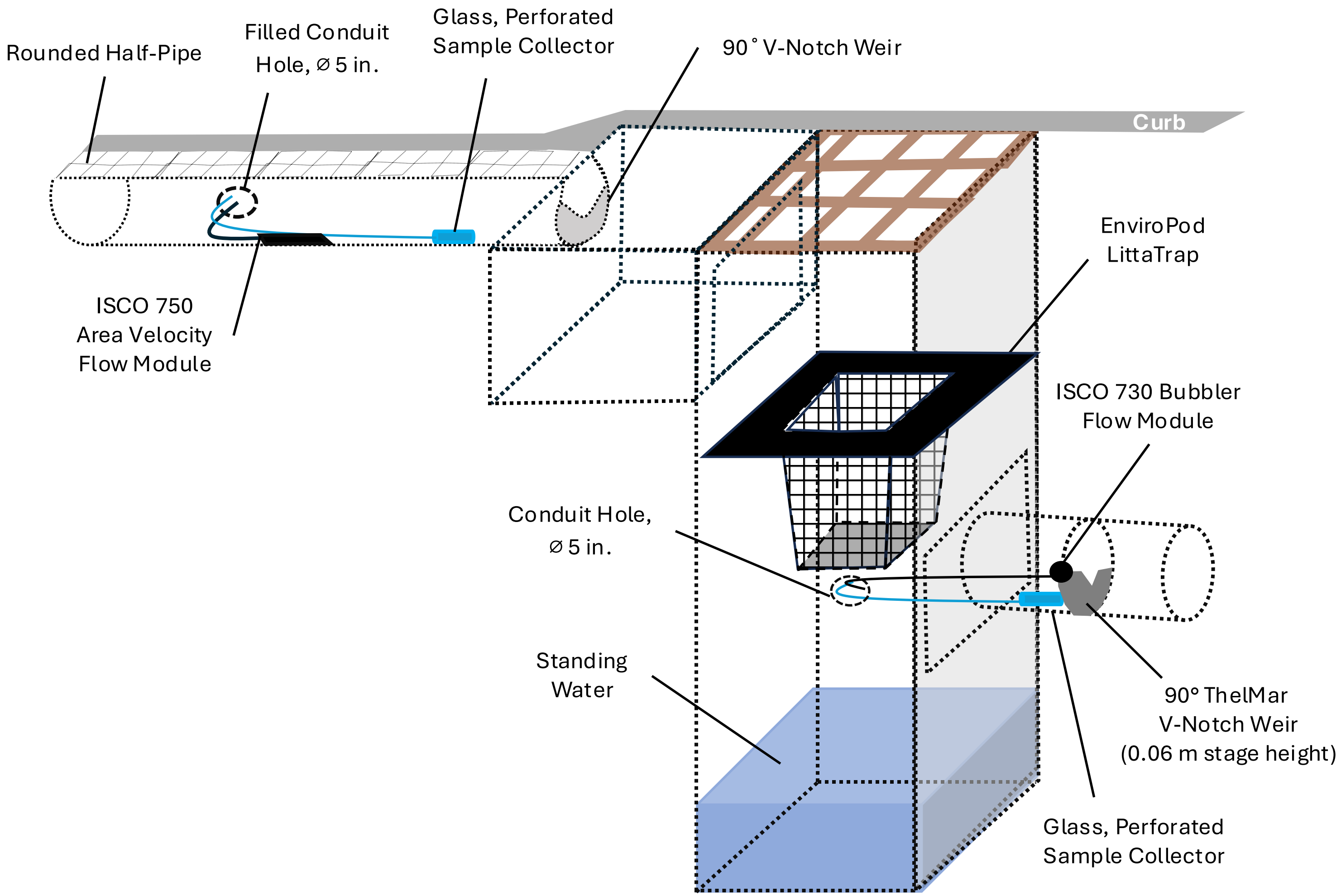

Methods: Field Testing

Storm Conditions and Sample Collection

Event Type	Date (2025)	Duration (minutes)	Influent and Effluent Sample Collection	Average Influent Flow Rate (L/s)	Total Rainfall Depth (mm)
Simulated	March 22	65	8 full bottles	0.35	NA
	April 11	73	13 full bottles	0.73	NA

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Methods: Field Testing

Storm Conditions and Sample Collection

Event Type	Date (2025)	Duration (minutes)	Influent and Effluent Sample Collection	Average Influent Flow Rate (L/s)	Total Rainfall Depth (mm)
Simulated	March 22	65	8 full bottles	0.35	NA
	April 11	73	13 full bottles	0.73	NA
Natural	April 5	73	24 full bottles	0.72	4.76
	April 21	52	24 full bottles	1.05	7.22

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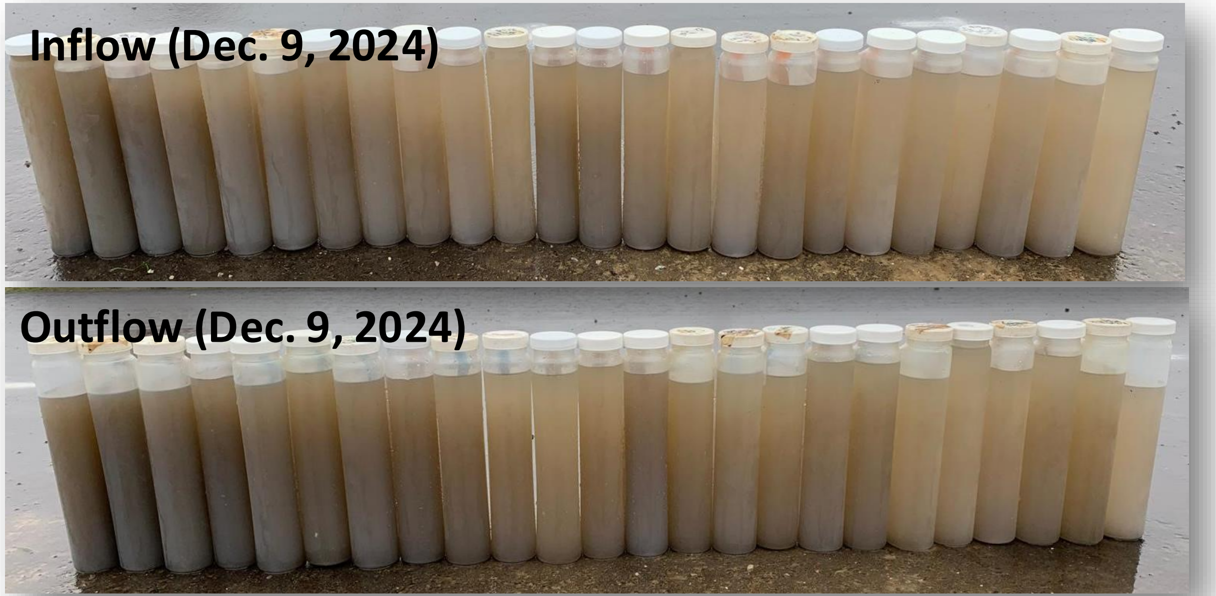
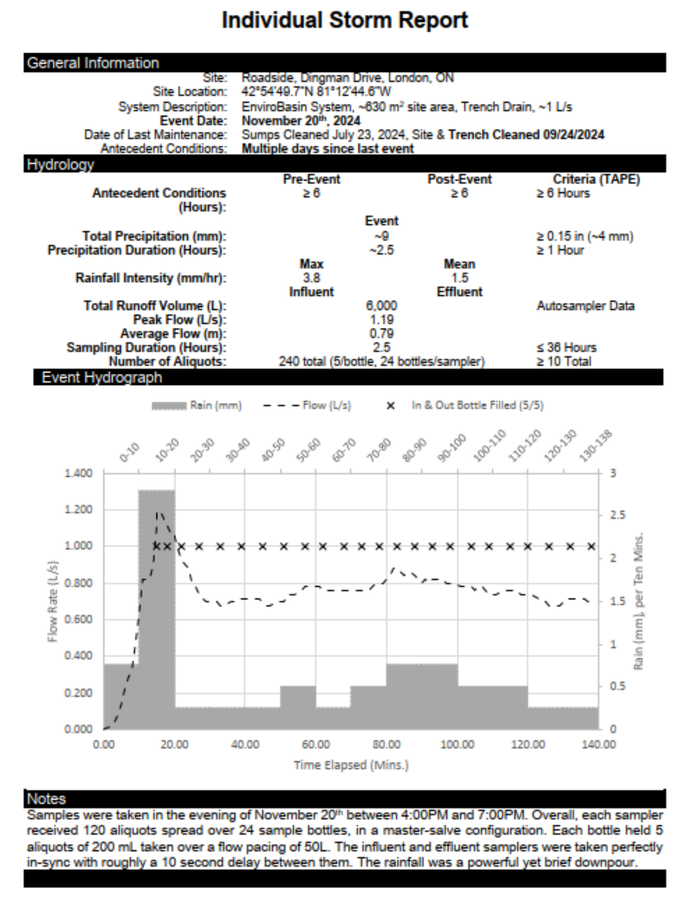
Methods: Field Testing

Storm Conditions and Sample Collection



24 L collected for inflow and 24 L collected for outflow



Individual Storm Report

General Information

Site:	Roadside, Dingman Drive, London, ON
Site Location:	42°54'49.7"N 81°12'44.6"W
System Description:	EnviroBasin System, ~630 m² site area, Trench Drain, ~1 L/s
Event Date:	**November 20th, 2024**
Date of Last Maintenance:	Sumps Cleaned July 23, 2024, Site & **Trench Cleaned 09/24/2024**
Antecedent Conditions:	**Multiple days since last event**

Hydrology

	Pre-Event		**Post-Event**	**Criteria (TAPE)**
Antecedent Conditions (Hours):	≥ 6		≥ 6	≥ 6 Hours
		Event		
Total Precipitation (mm):		~9		≥ 0.15 in (~4 mm)
Precipitation Duration (Hours):		~2.5		≥ 1 Hour
	Max		**Mean**	
Rainfall Intensity (mm/hr):	3.8		1.5	
	Influent		**Effluent**	
Total Runoff Volume (L):		6,000		Autosampler Data
Peak Flow (L/s):		1.19		
Average Flow (m):		0.79		
Sampling Duration (Hours):		2.5		≤ 36 Hours
Number of Aliquots:		240 total (5/bottle, 24 bottles/sampler)		≥ 10 Total

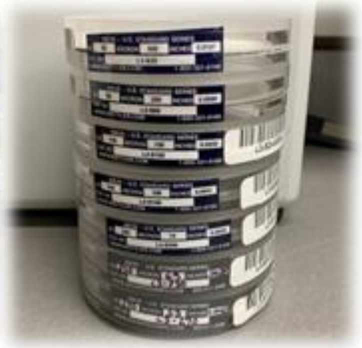
Event Hydrograph

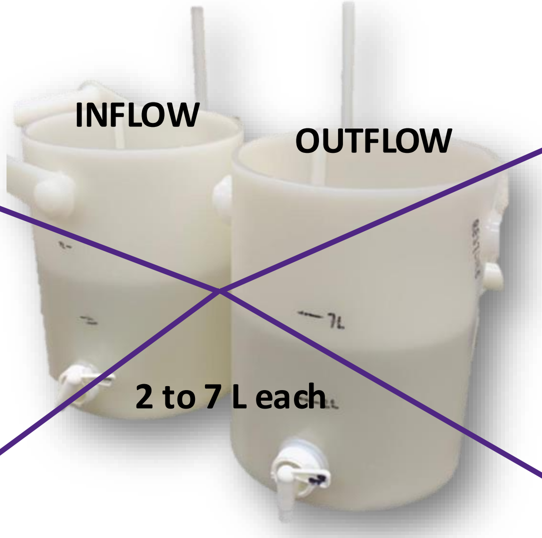
Notes

Samples were taken in the evening of November 20th between 4:00PM and 7:00PM. Overall, each sampler received 120 aliquots spread over 24 sample bottles, in a master-salve configuration. Each bottle held 5 aliquots of 200 mL taken over a flow pacing of 50L. The influent and effluent samplers were taken perfectly in-sync with roughly a 10 second delay between them. The rainfall was a powerful yet brief downpour.

Methods: Sample Analysis

Particle Size Distribution (PSD)
(Modified ASTM D3977-97B/C)
Sample volume required: ≥ 1 L





PSD (Laser Diffraction)
Sample volume required: ≥ 1 L

Total Suspended Solids (TSS) (SM 2540D)
Sample volume required: ≥ 100 mL

Suspended-sediment Concentration
(SSC) (SM 2540D)
Sample volume required: ≥ 1 L

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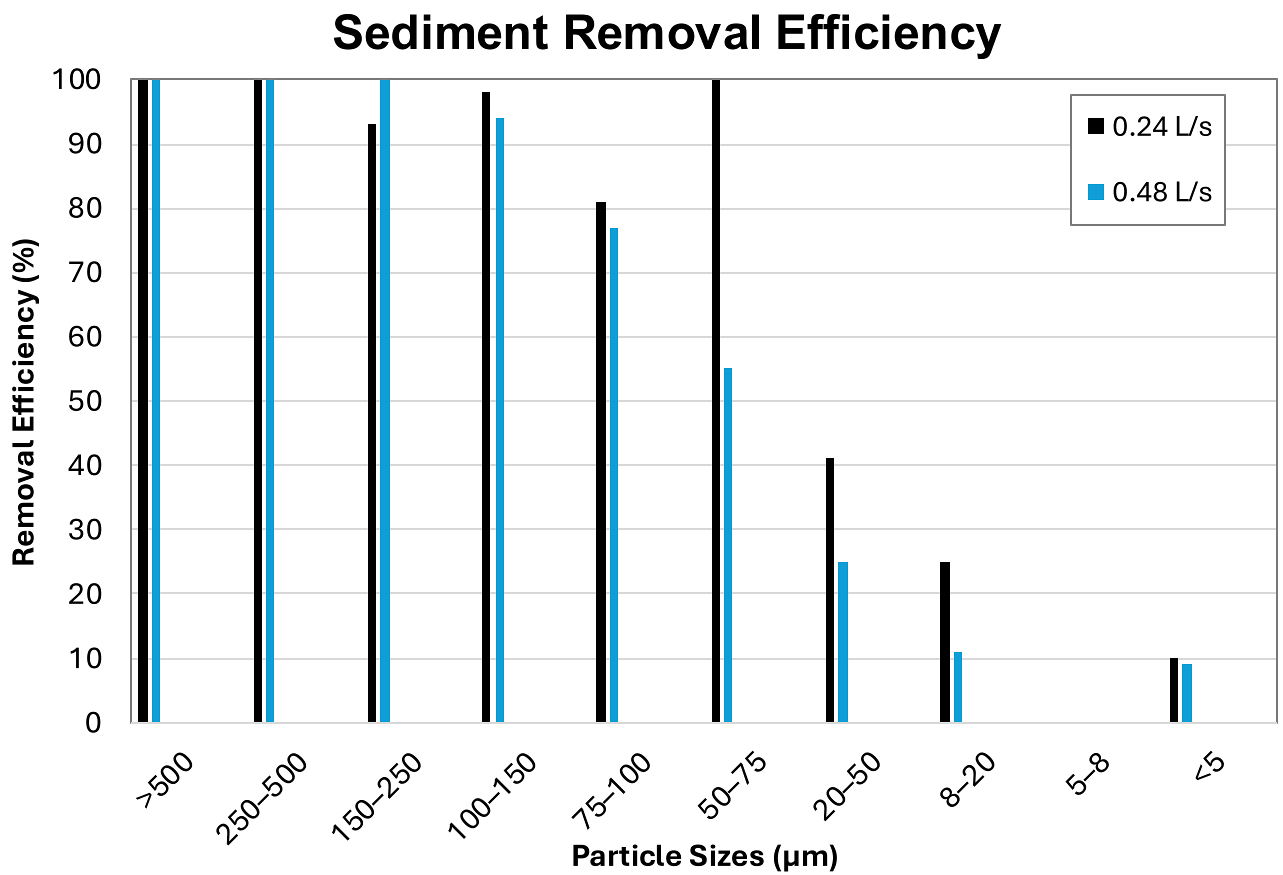
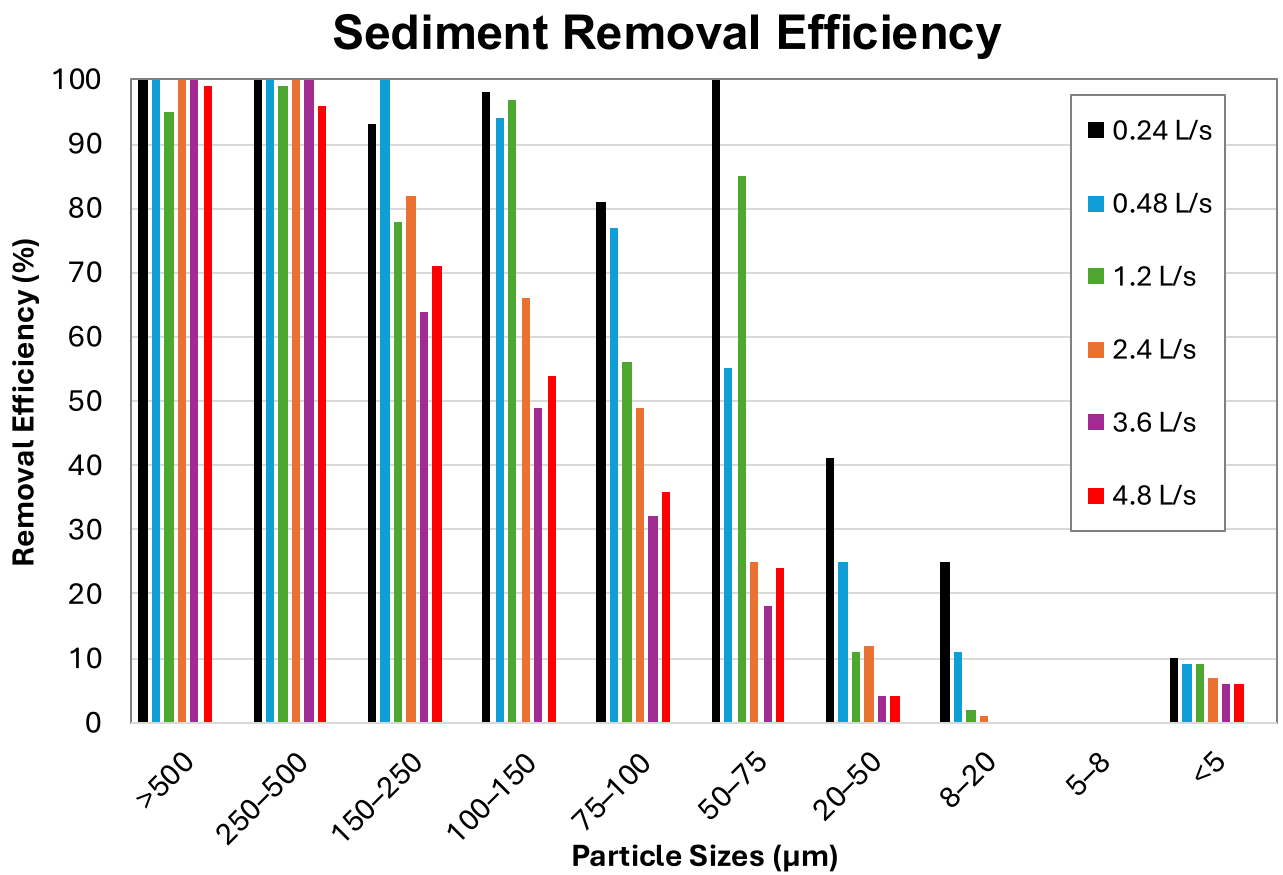
Preliminary Testing: Laboratory

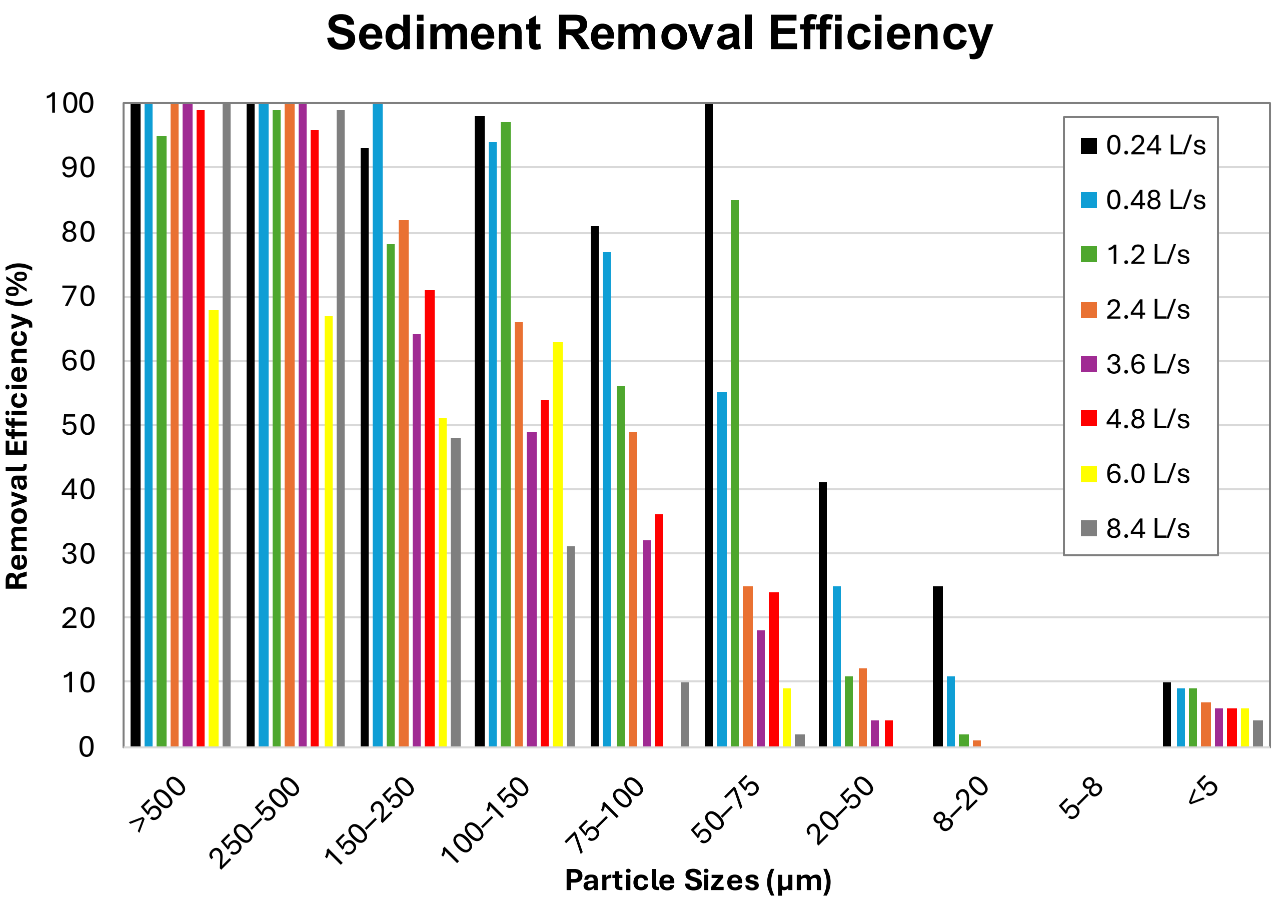


Preliminary Testing: Laboratory



Preliminary Testing: Laboratory

- Removal efficiency strongly influenced by particle size and flow rate.
- Lowest performance observed at highest tested flow rate (8.4 L/s)
- Low removal of fine particles (<50 µm) with efficiencies with close to zero removal at higher flow rates.



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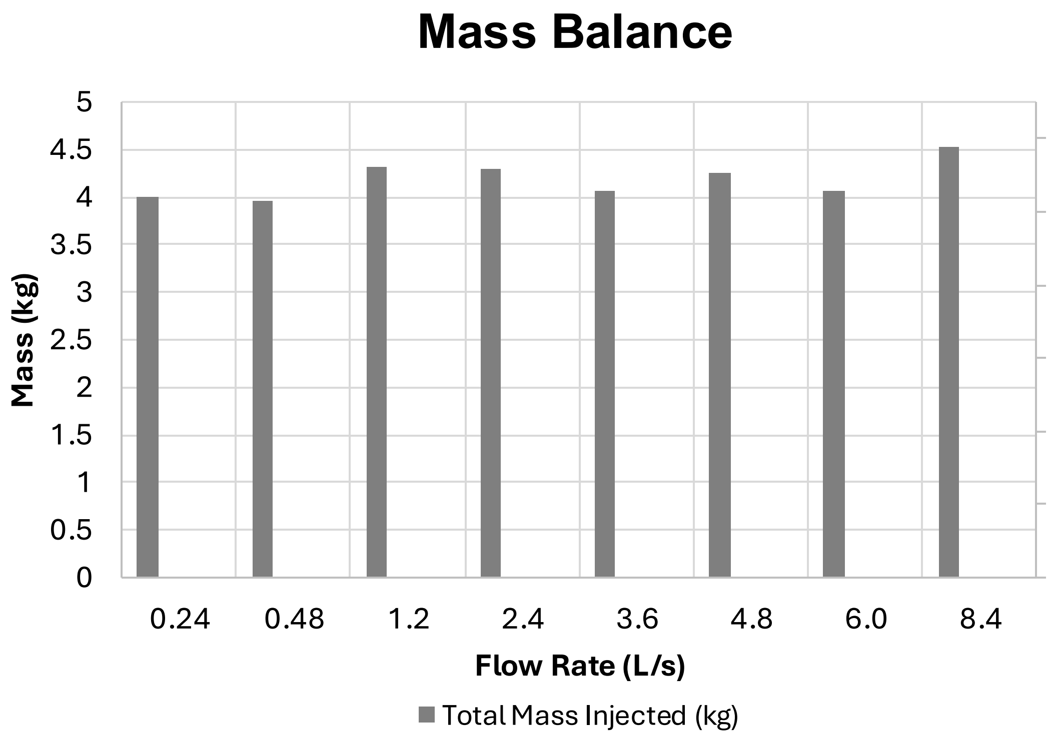
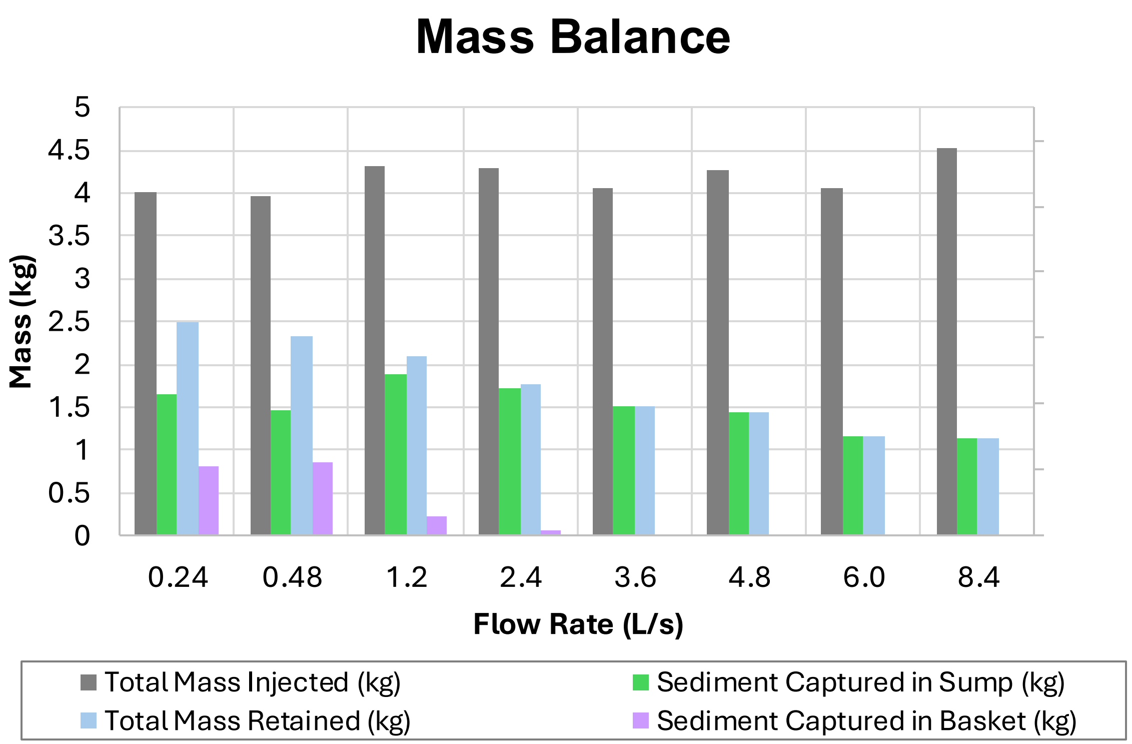
Preliminary Testing: Laboratory



Preliminary Testing: Laboratory



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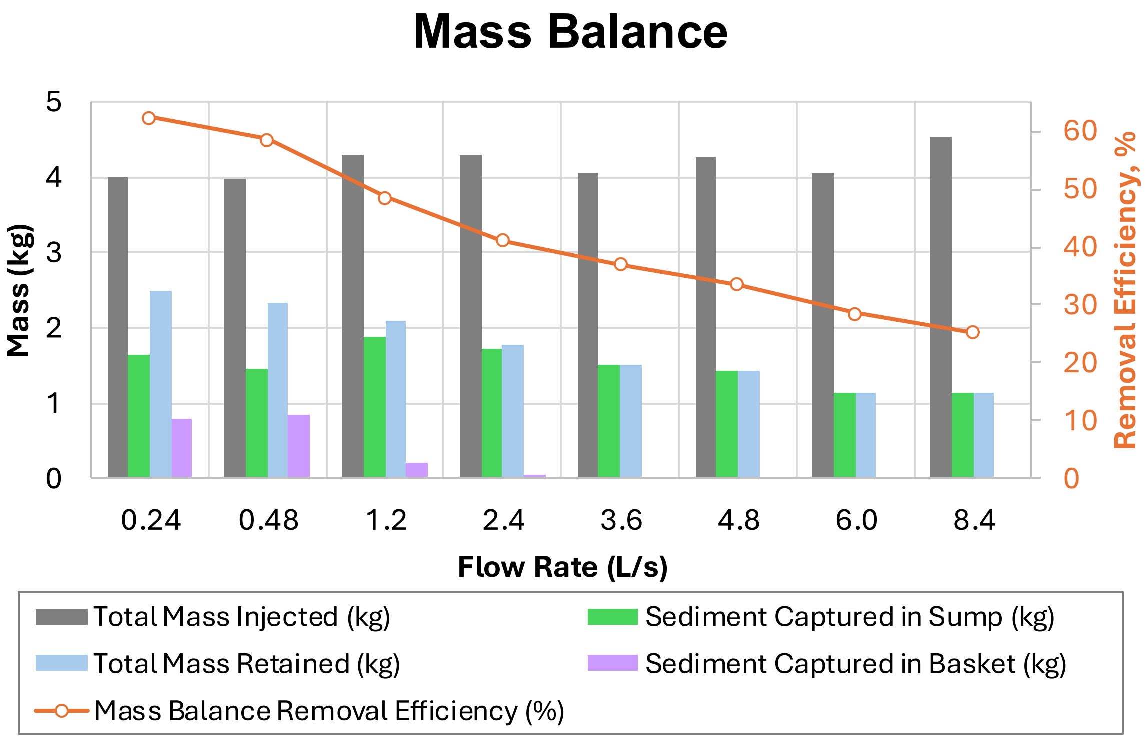
Preliminary Testing: Laboratory

- At lower flow rates, overall higher removal efficiency is due to sediment being captured in mesh basket.
- At higher flow rates, sediment is only captured in the sump and overall removal efficiency declines.



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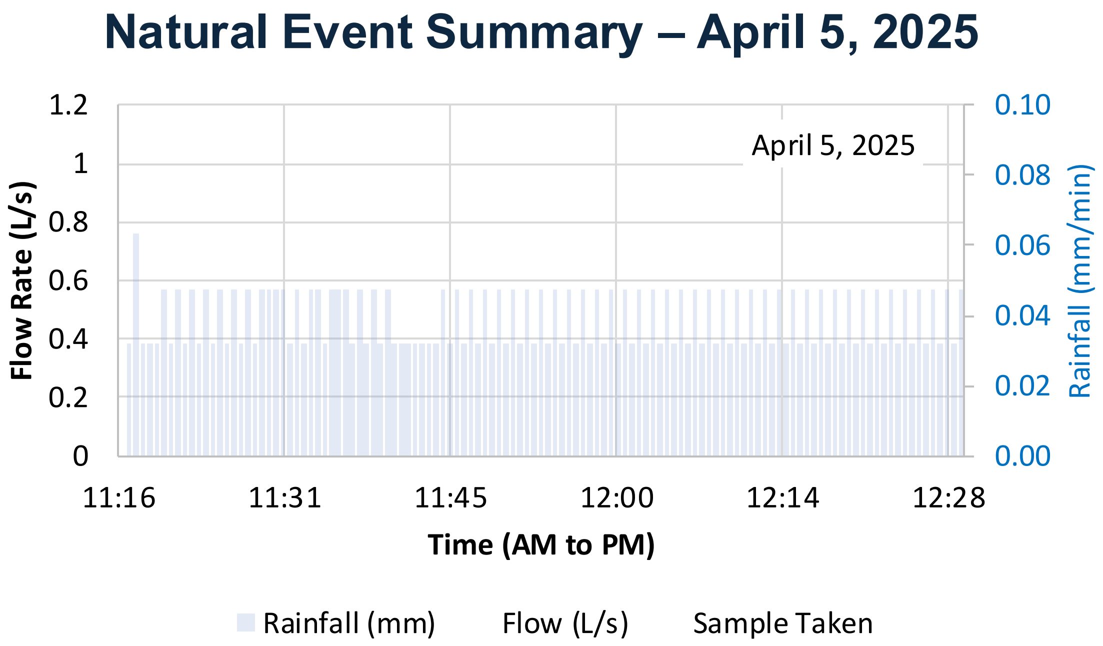
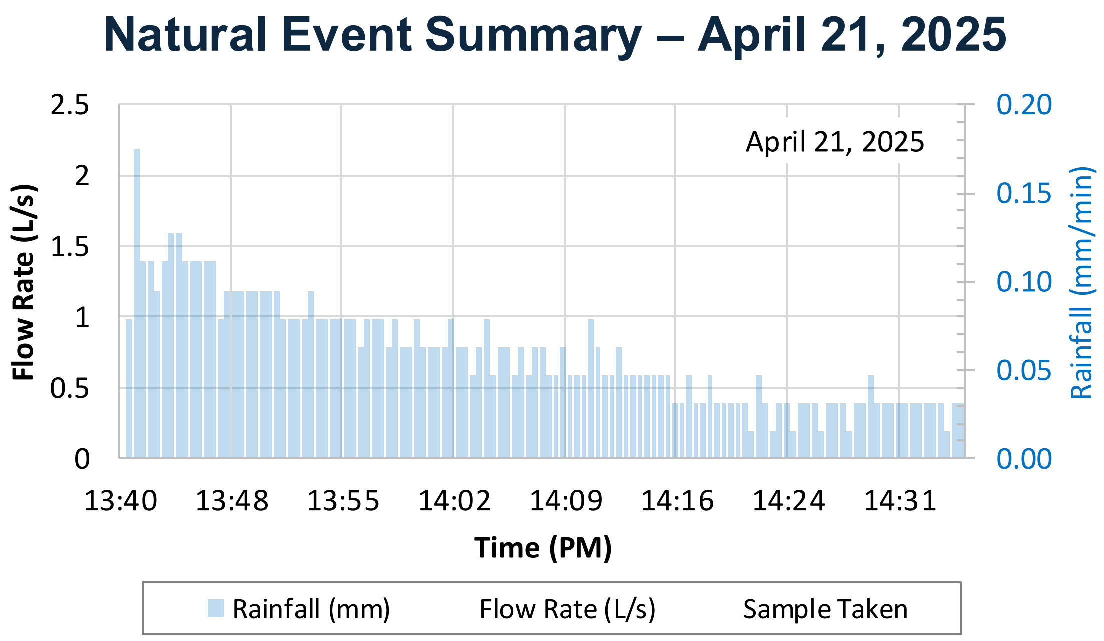
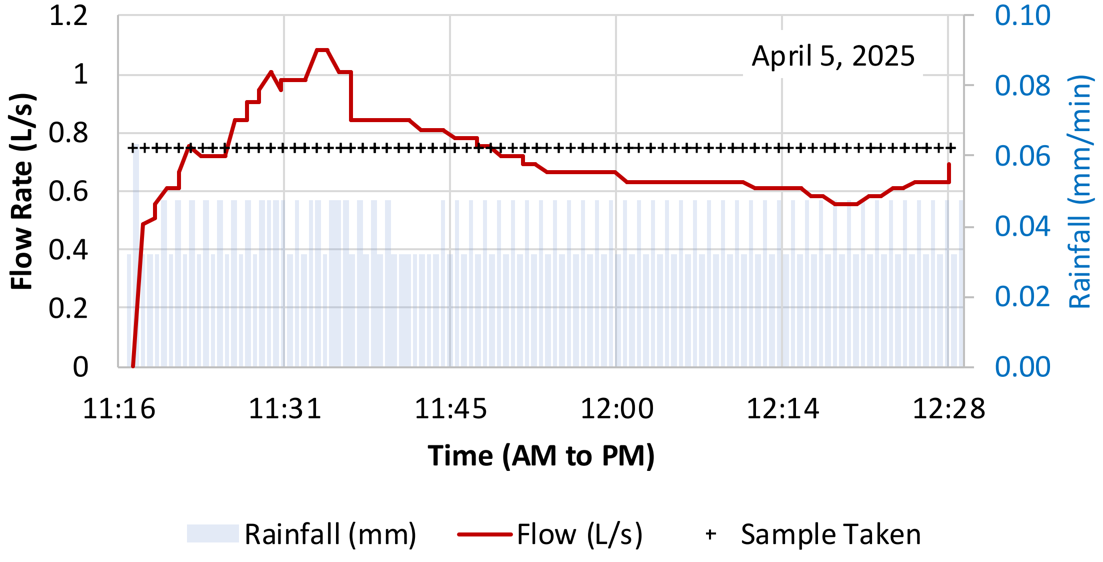
Preliminary Testing: Field Events



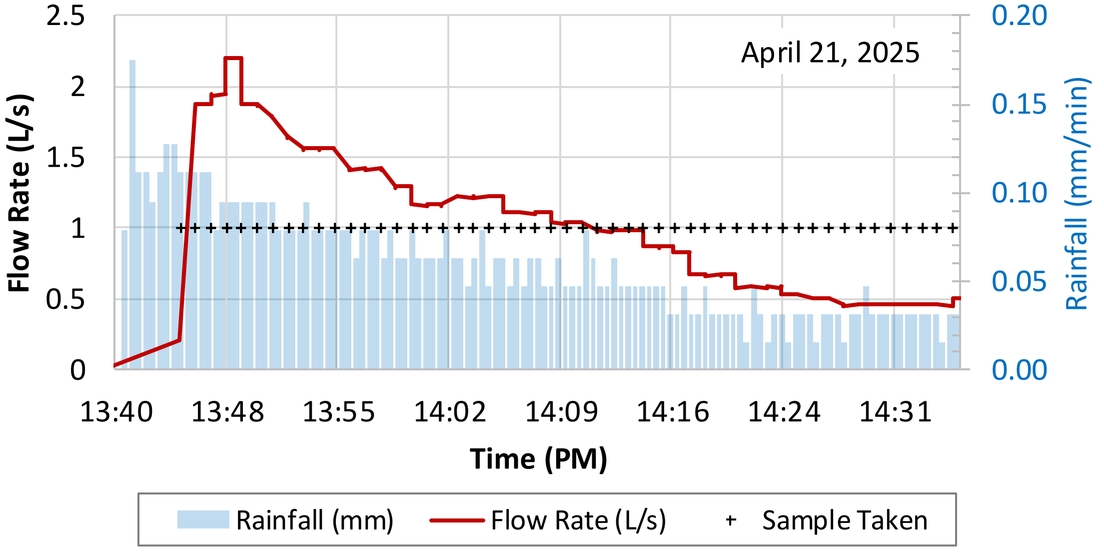


Preliminary Testing: Field Events

Natural Event Summary – April 5, 2025



Natural Event Summary – April 21, 2025



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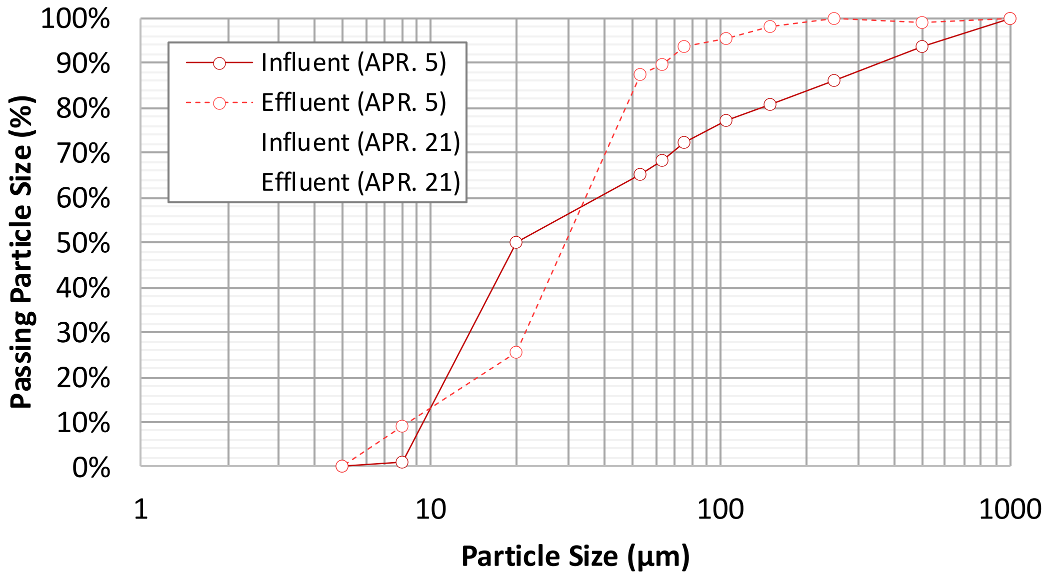
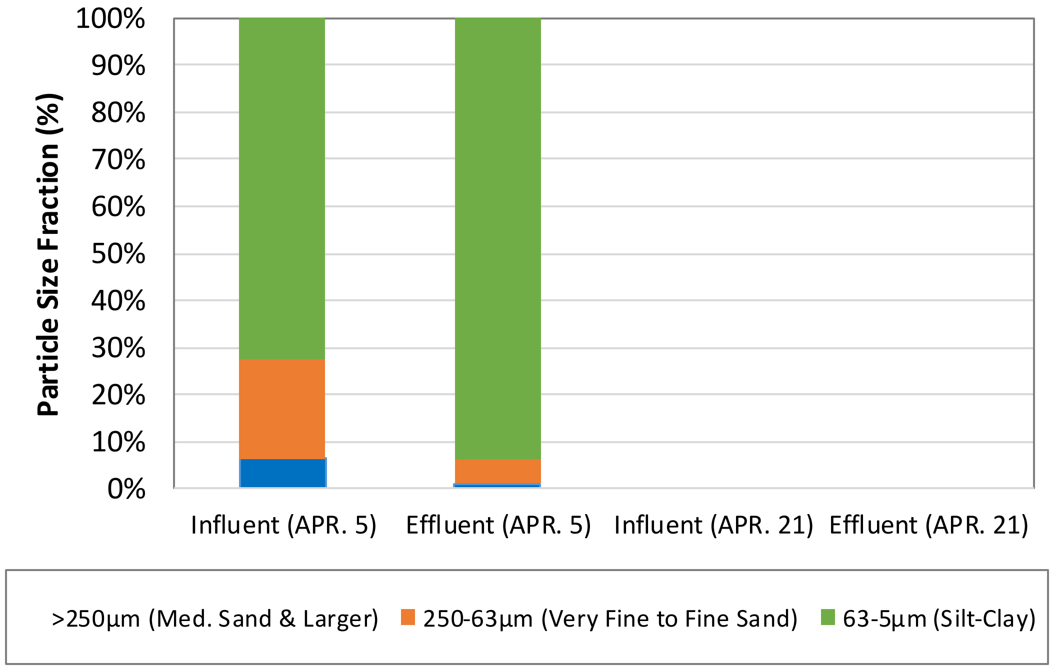
Preliminary Testing: Field Events

Sediment PSD



PSD Categorization



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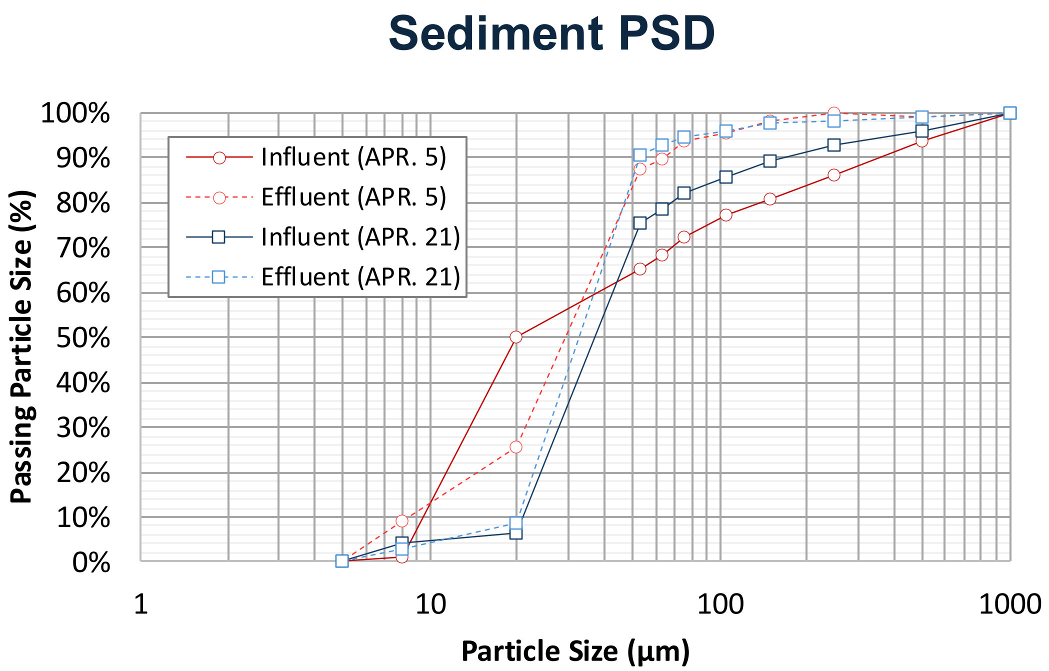
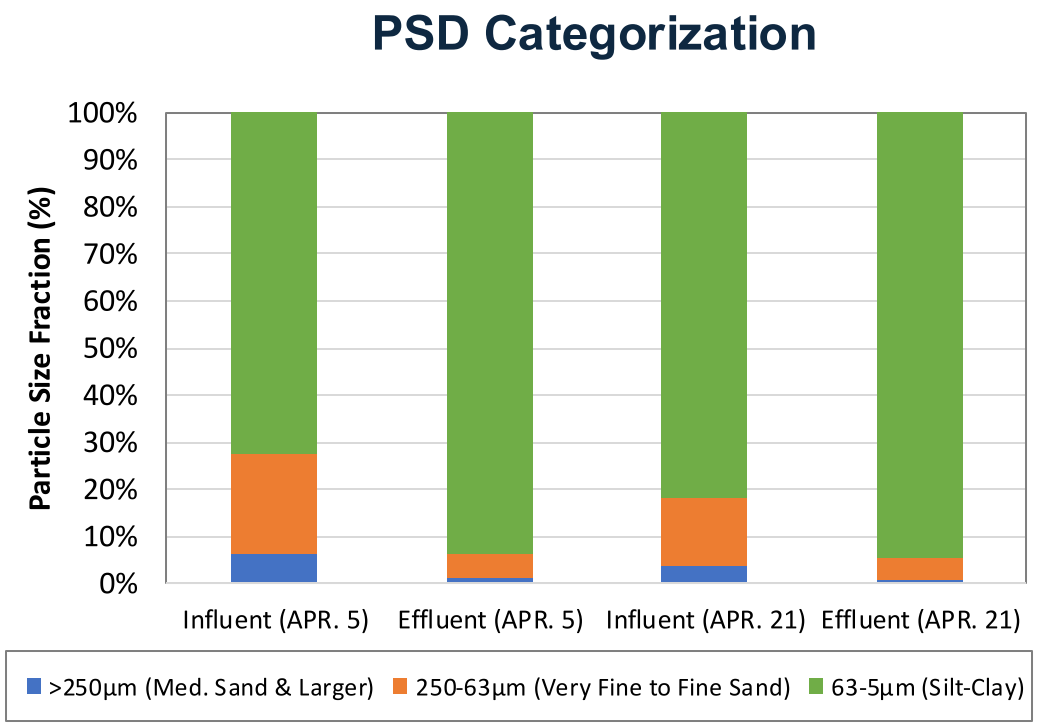
Preliminary Testing: Field Events





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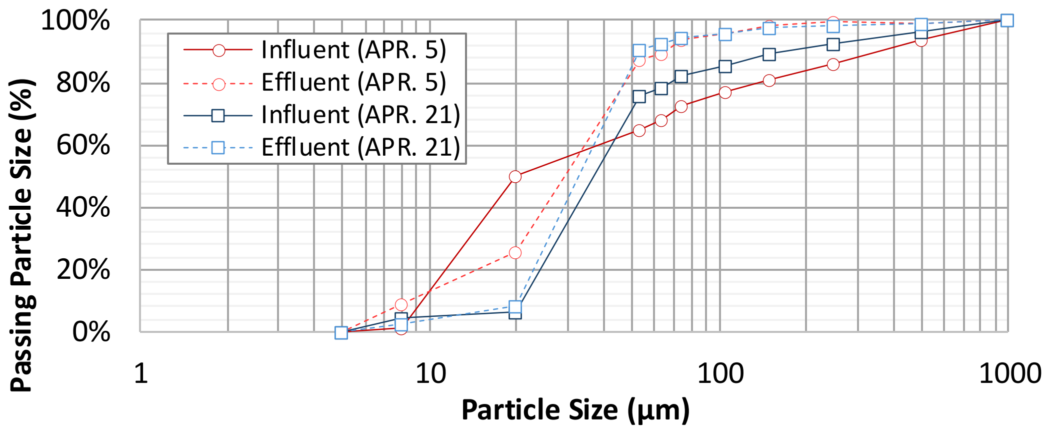
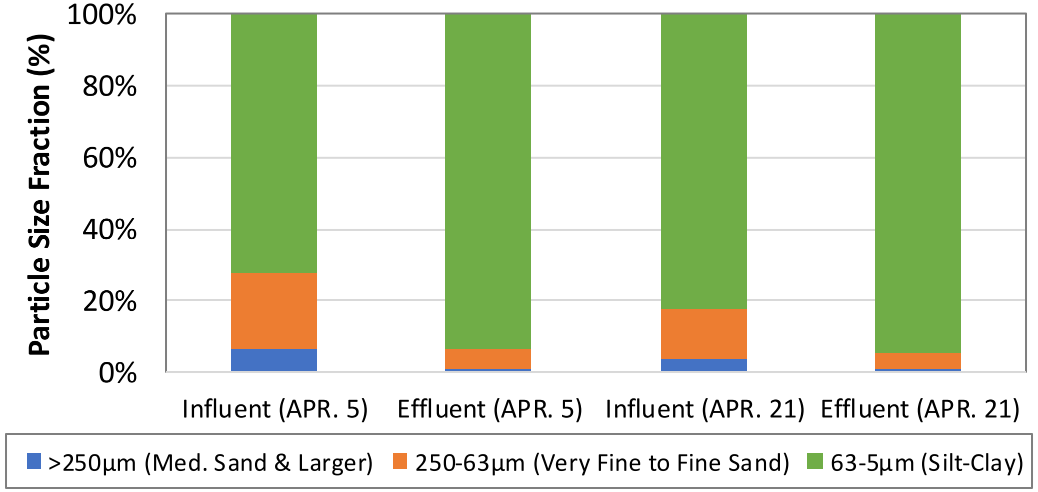
Preliminary Testing: Field Events

- PSD for effluent samples were similar for both events indicating consistent performance
- EnviroBasin able to provide high removal for coarser sediment

Sediment PSD, and PSD Categorization





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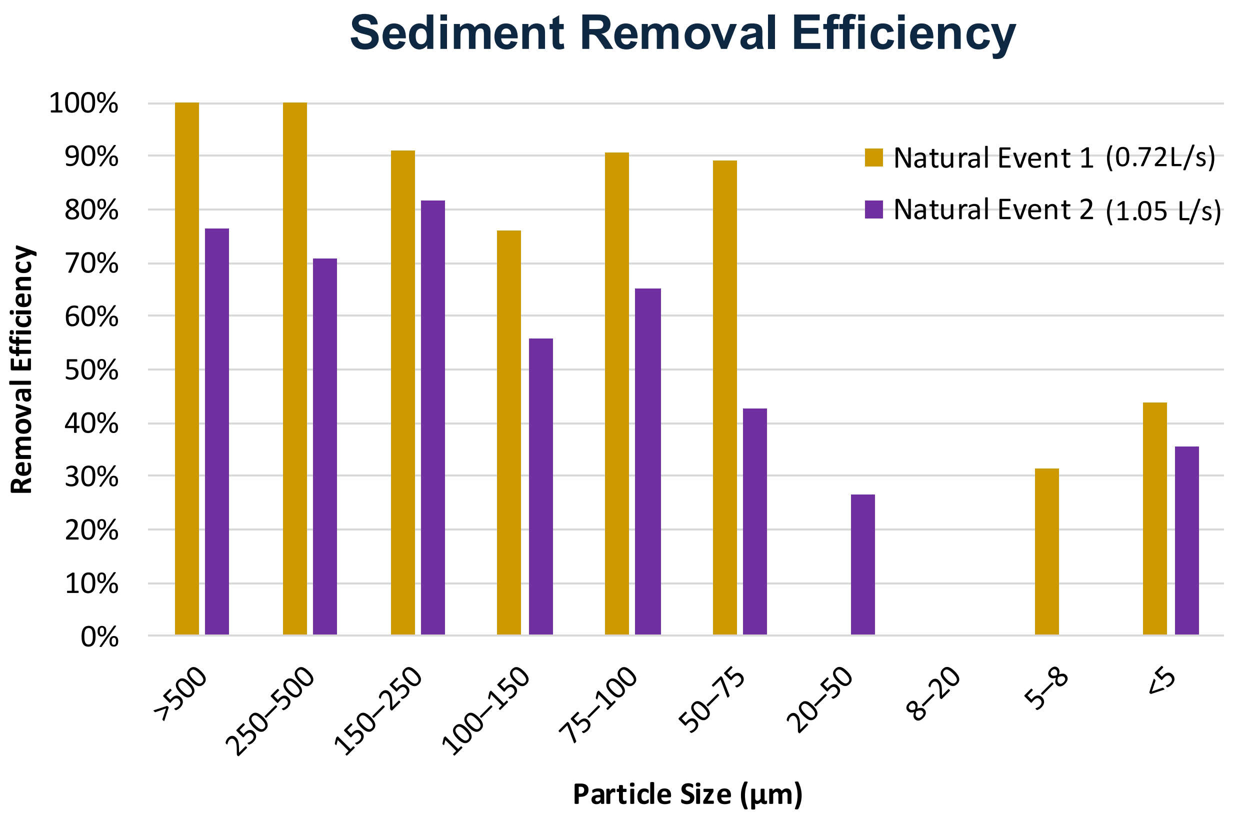
Preliminary Testing: Field Events

- High removal efficiency (>75%) for all particle size ranges > 50 µm. Low removal efficiencies for smaller particles.



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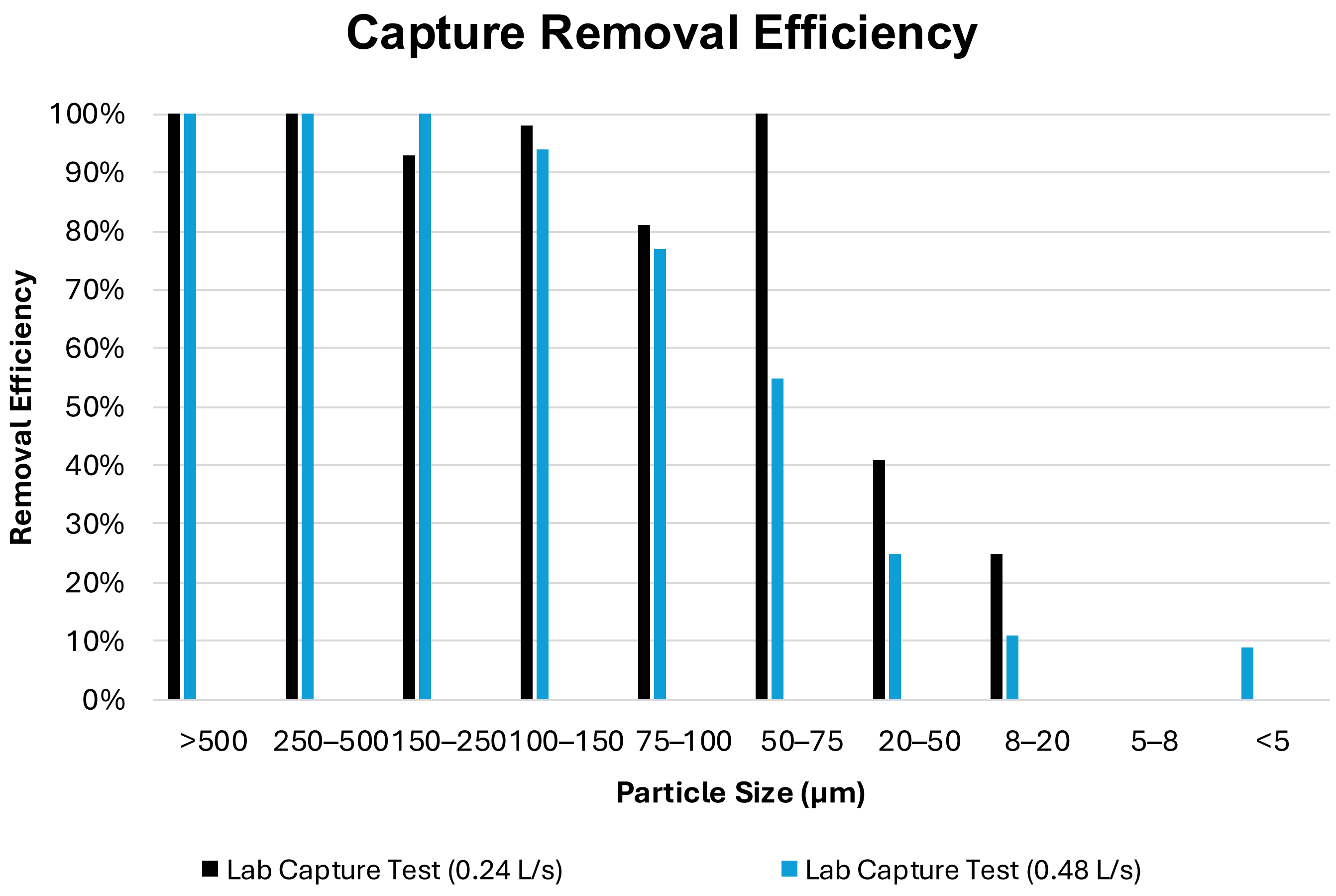
Preliminary Testing: Laboratory vs Field



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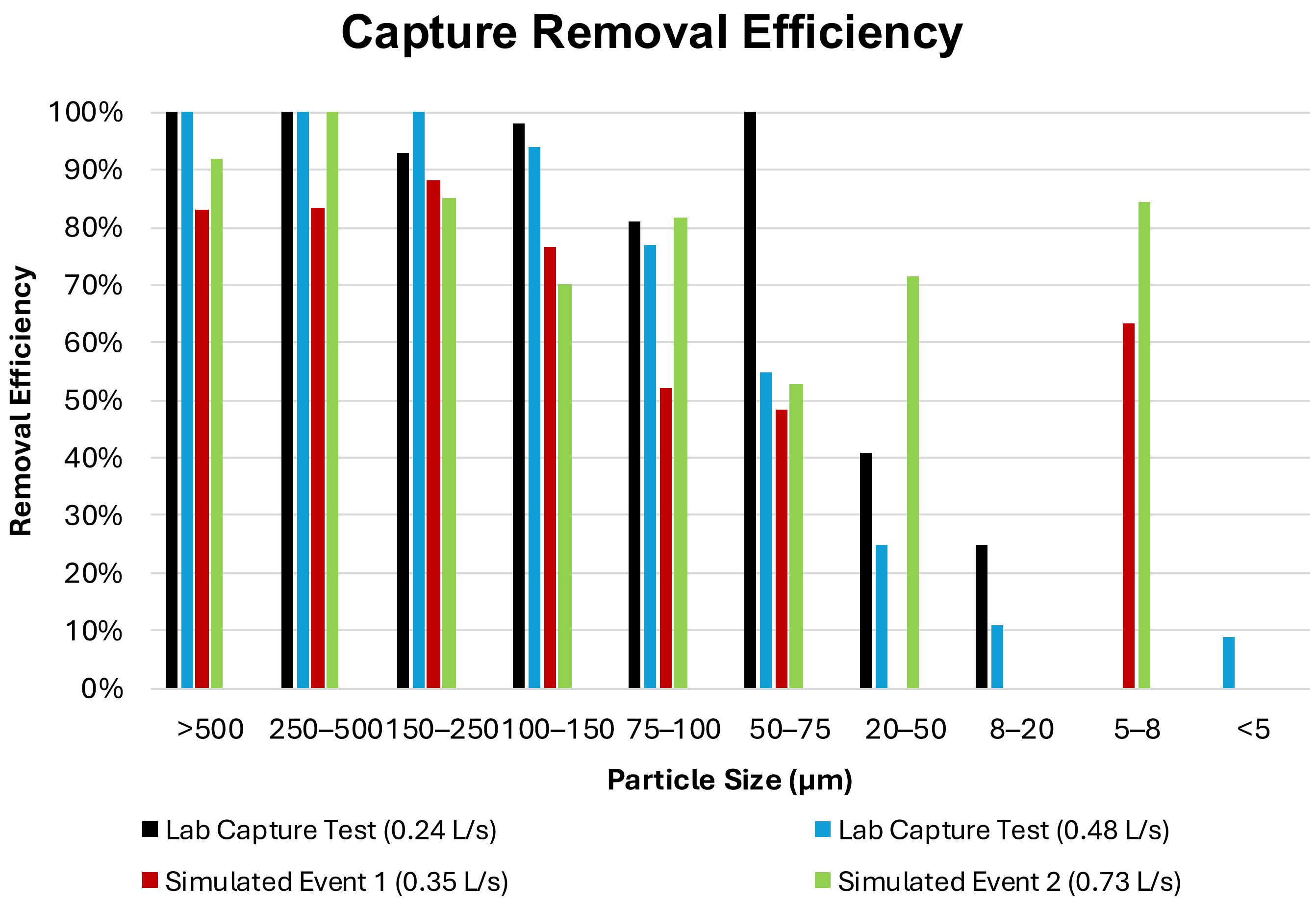
Preliminary Testing: Laboratory vs Field



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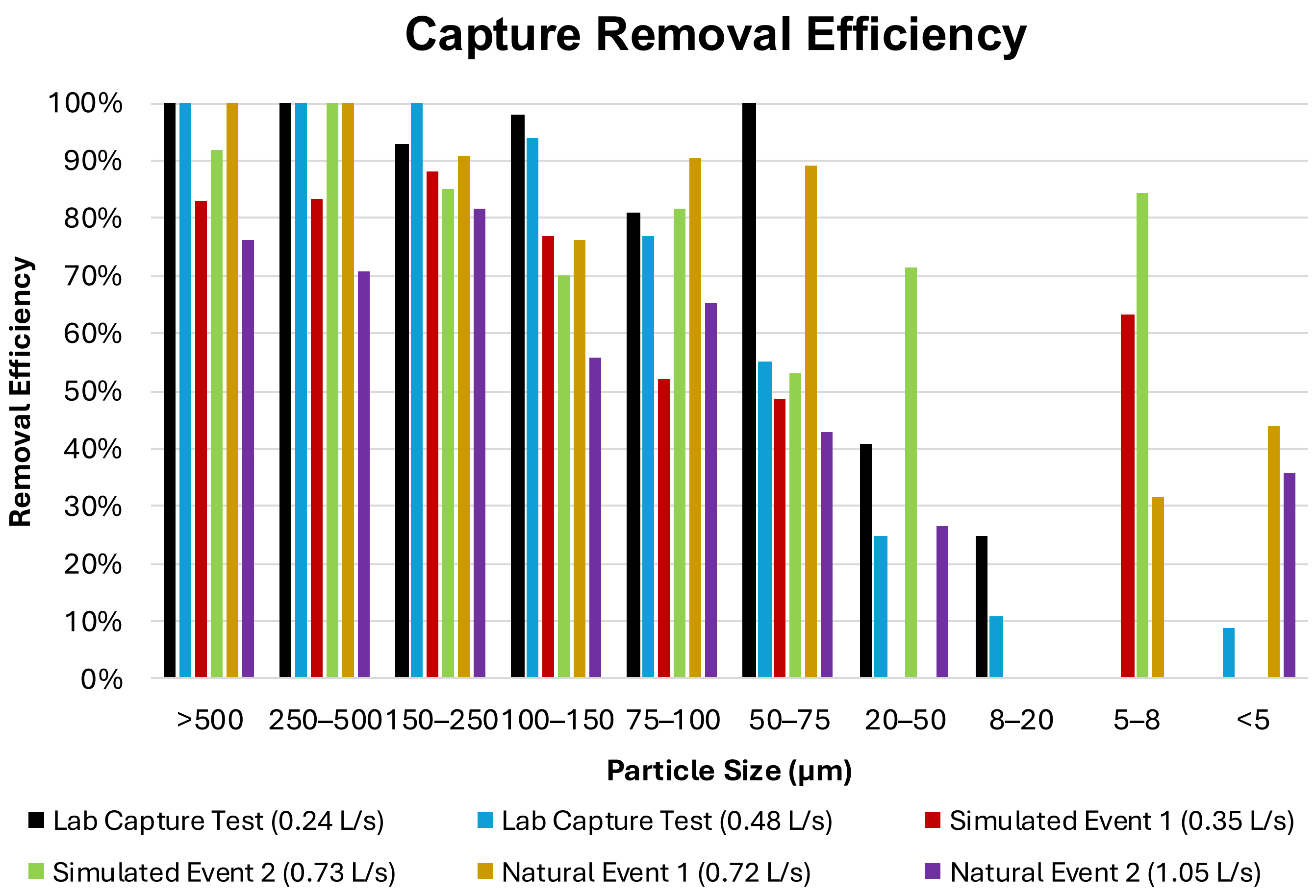
Preliminary Testing: Laboratory vs Field

- Removal efficiencies across events similar for particle sizes > 75-100 µm.
- For finer particles (<75 µm), removal efficiencies higher in laboratory tests compared to field tests.



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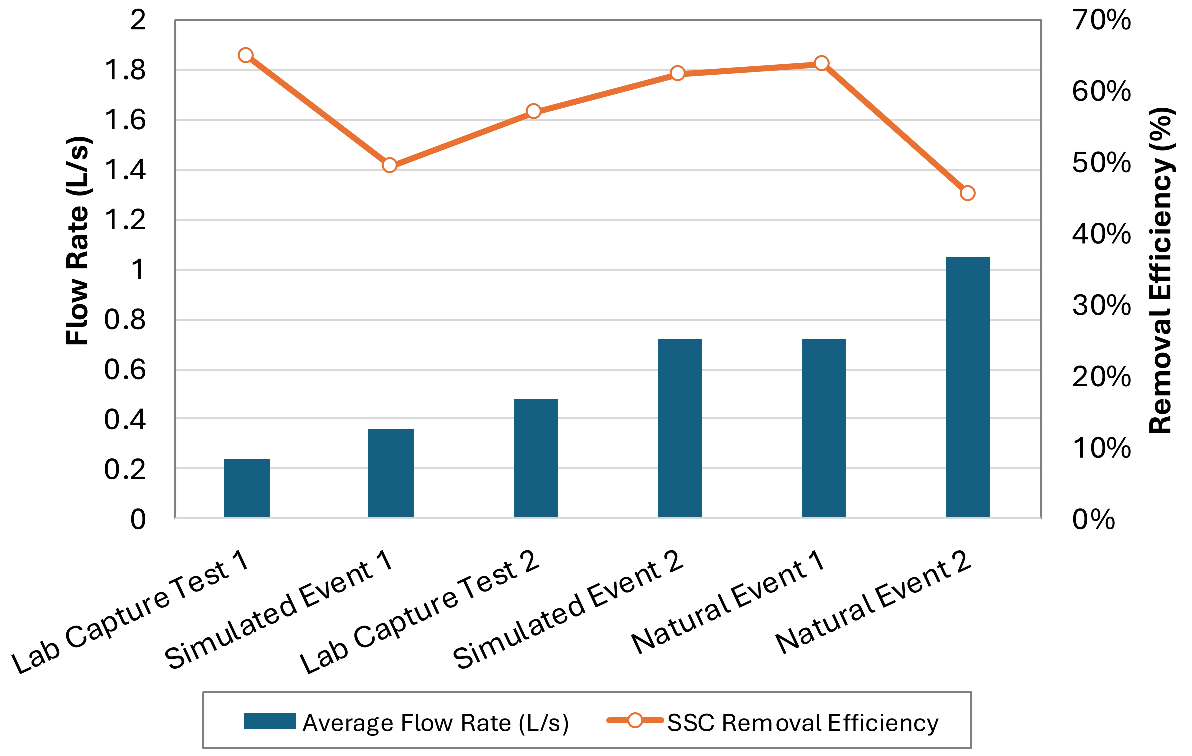
Preliminary Testing: Laboratory vs Field

- Data indicate EnviroBasin able to provide consistent sediment retention across laboratory and field settings, and for varying sediment composition and flow rate.
- Effluent PSD consistent between field and lab testing, regardless of influent.

SSC removal efficiencies and flow rates for all tests and events (flow rates less than 2.4 L/s)



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Preliminary Testing: Conclusion

- Preliminary laboratory and field testing demonstrate the clear potential of the EnviroBasin for efficiently removing sediment particle sizes greater than 75 µm.

- However, this is based on laboratory testing and only two natural events from April 2025. The EnviroBasin now needs to be examined for its *long-term effectiveness* across multiple seasons in a cold Canadian climate.

Background

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Long-Term Performance

Background: Seasonal Variation

Why is seasonal variation important, especially for a study based in Canada?

Winter

Accumulation of precipitation stores runoff pollutants

Spring

Rapid snowmelt and rainfall causes high runoff volumes

Summer

Short but intense storm events

Fall

High volumes of leaves and organic matter in runoff

Precipitation patterns, temperature, and land surface conditions change throughout the year, all of which strongly influence how stormwater systems perform (Westerlund et al., 2008).

Long-Term Performance

Background: Seasonal Variation and Cold Climates

- Accumulation of precipitation (i.e. snowpack) in cold climate regions can store suspended solids, metals, nutrients and other pollutants (Westerlund et al., 2008).
- Large pollutant loads can be released at the same time during warming temperatures (Blecken et al., 2012).
- Road salts can mobilize/displace metals and nutrients within sediments (Hodgins et al., 2023)

Long-Term Performance

Background: Metal and Nutrient Removal

- Heavy metals are attached to suspended solids in stormwater runoff (Herngren et al., 2005).
- Multiple studies have studied the correlation of maximum pollutant loads in the smallest particle size fractions: <37 um (Fujiwara et al., 2011), <75 um (Herngren et al., 2005), and <150 um (Zhao et al., 2013).
- Metal concentrations generally increase as particle size decreases, highlighting the need for effective treatment of direct stormwater runoff (Djukic et al., 2015).
- Do we reduce metal concentration alongside sediment removal?

Long-Term Performance

Background: Metal and Nutrient Removal

- Prolonged leaf litter saturation in catch basins or stormwater networks enhances the nutrient leaching and decomposition processes that mobilize nutrients (Hobbie et al., 2014).
- Extended saturation accelerates nutrient release, making organic debris a potential non-point source pollutant (Duan et al., 2014).
- Does the EnviroBasin acts as a source or sink for nutrients?

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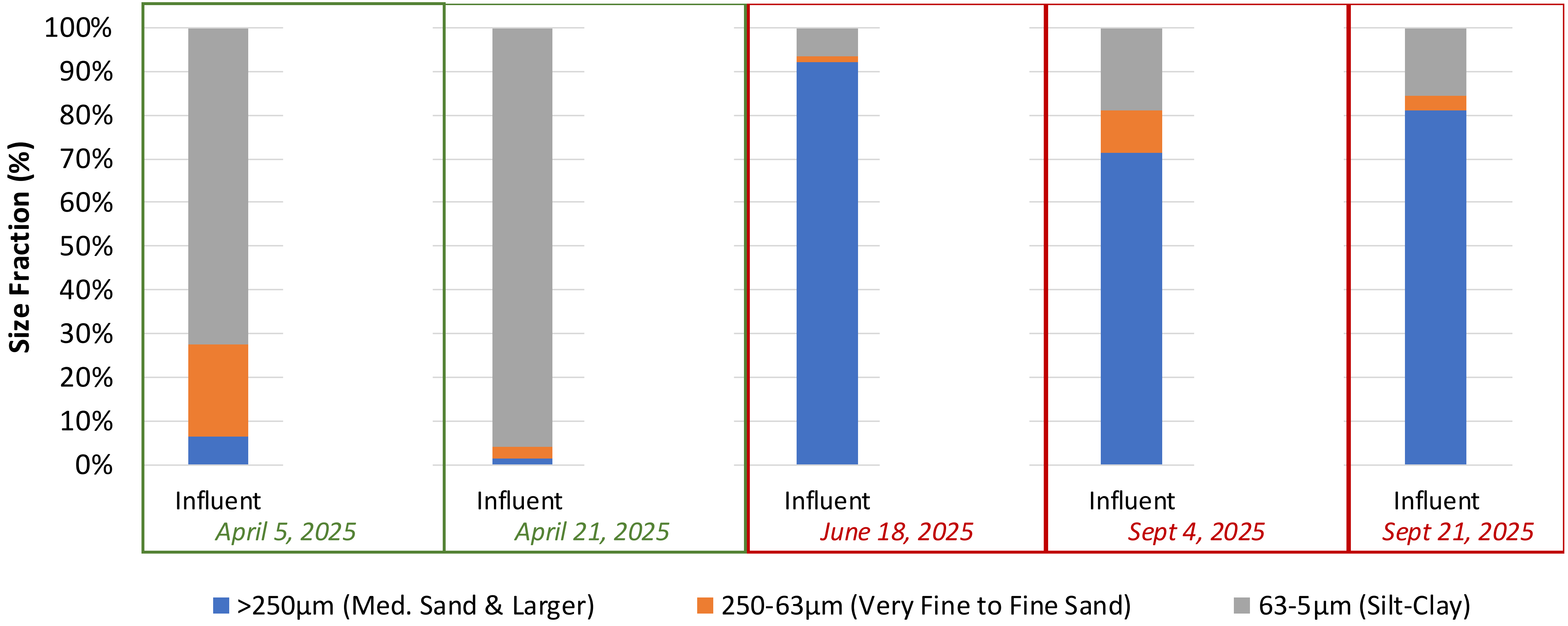
Long-Term Performance

Results: Particle Size Distribution

- There is variation in particle size from spring to summer and late summer events.



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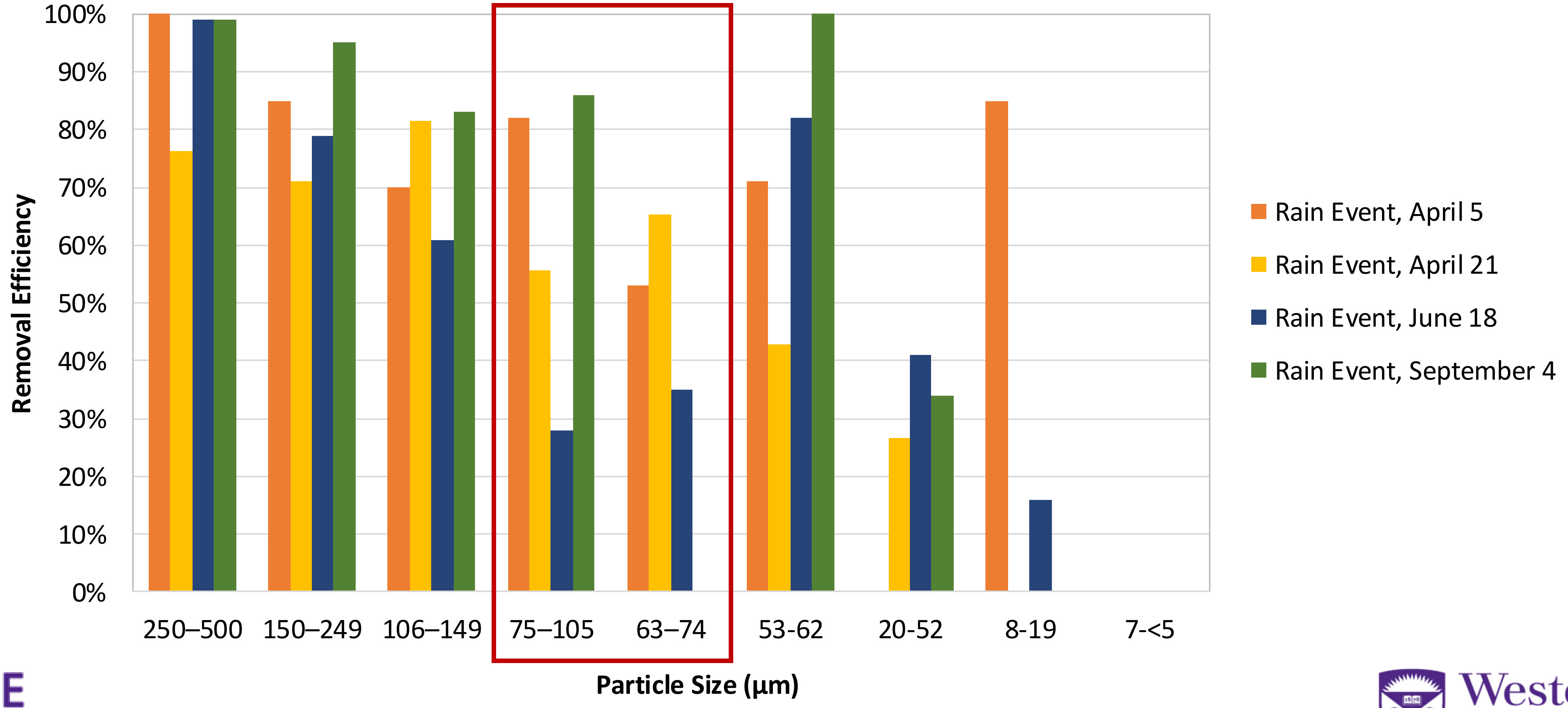
Results: Suspended Sediment Concentration

- There is removal down to the 75-um sieve.



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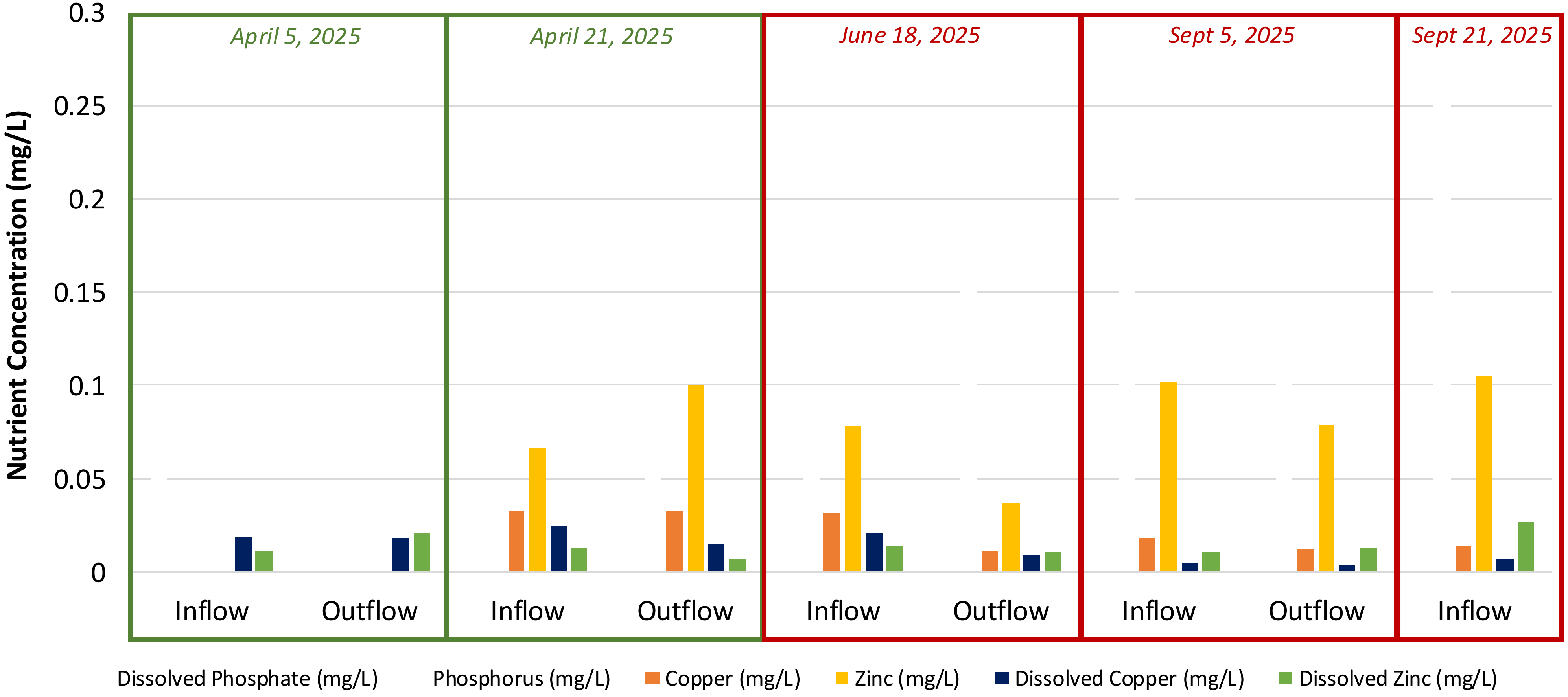
Results: Metal and Nutrient Removal

- There is an increase in metals and nutrients in the summer season when compared to spring



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Long-Term Performance

Results: Metal and Nutrient Removal

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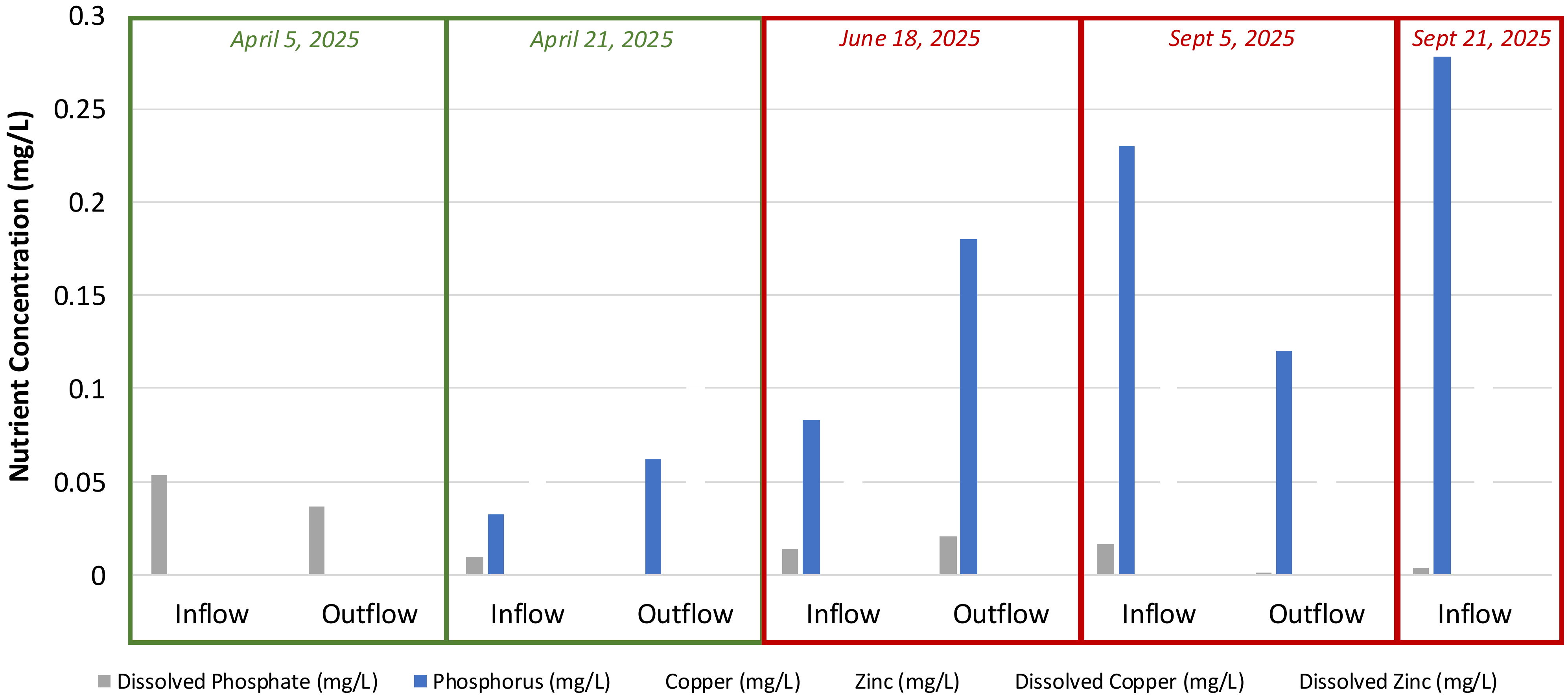

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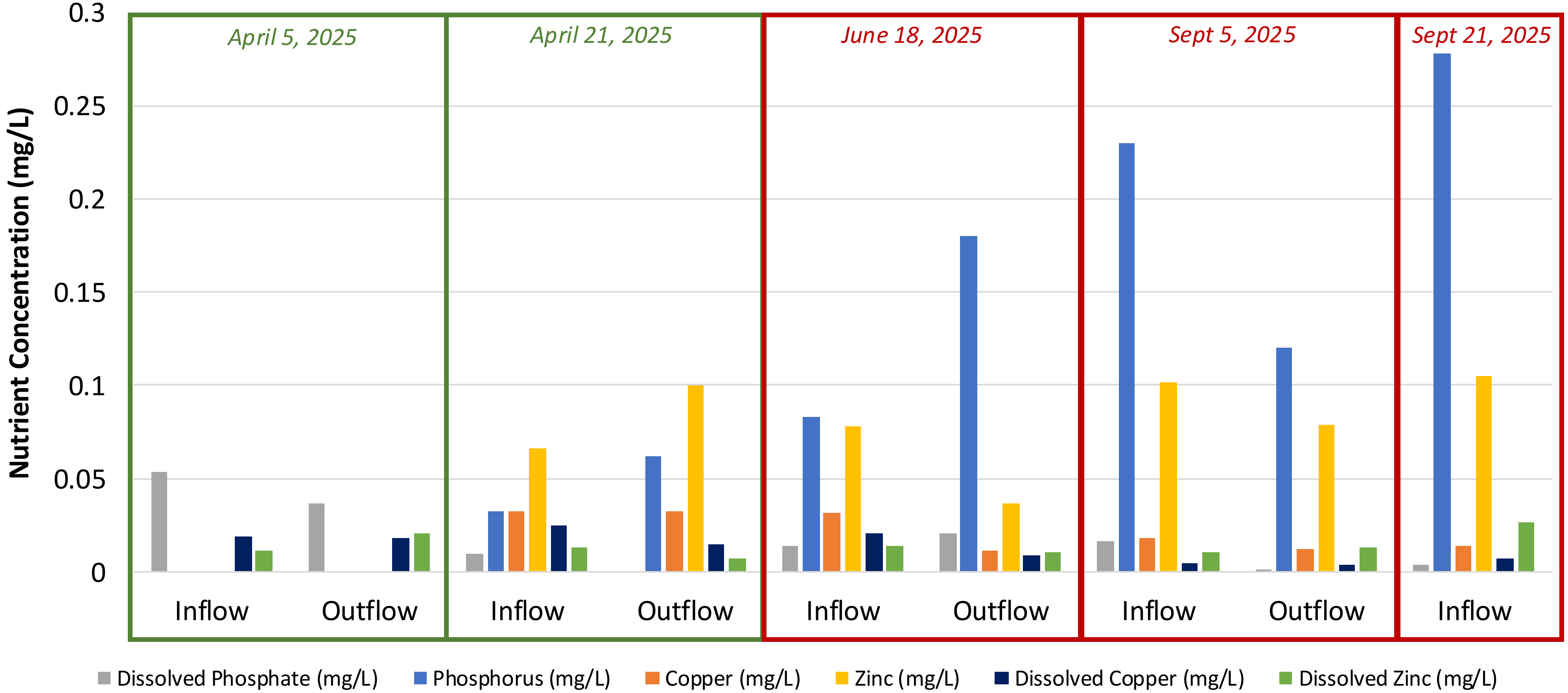
Long-Term Performance

Results: Metal and Nutrient Removal

- There is an increase in metals and nutrients in the summer season when compared to spring



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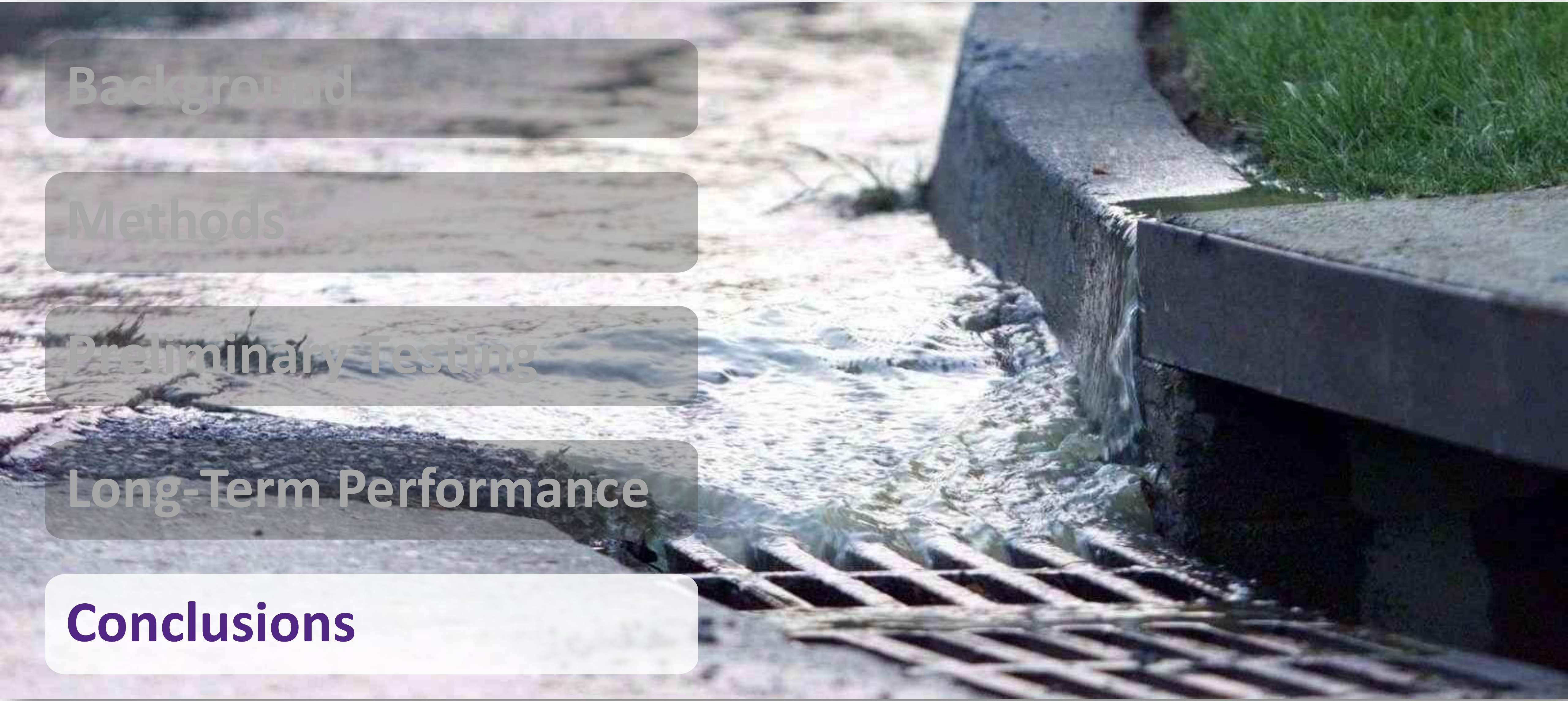
Background
Methods
Preliminary Testing
Long-Term Performance
Conclusions

Conclusions

- Laboratory and preliminary field testing showcase the potential of the EnviroBasin to remove suspended solids
- Long-term monitoring is needed to assess the EnviroBasin across varying seasons in a cold climate
- In addition to sediment removal, this study will assess the potential removal of metals and nutrients
- So far, this study has shown the variation in sediment loading across spring and summer

Thank you!

Questions?

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