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Groupe ROUSSEAU LEFEBVRE design + environment

SOIL WATER CONTENT AND PLANT SURVIVABILITY IN BIORETENTION CELLS

Mélanie Glorieux, Landscape Architect, M. Ing., SITES AP
Partner

SITES AP

www.rousseau-lefebvre.com

Who we are

Multidisciplinary team for applied sustainable development

R&D Mission

Performance evaluation of landscape projects

Understand behavior in the short and long term, and at all stages

> Design
> Construction
> Maintenance

Bioretention – thrive not survive

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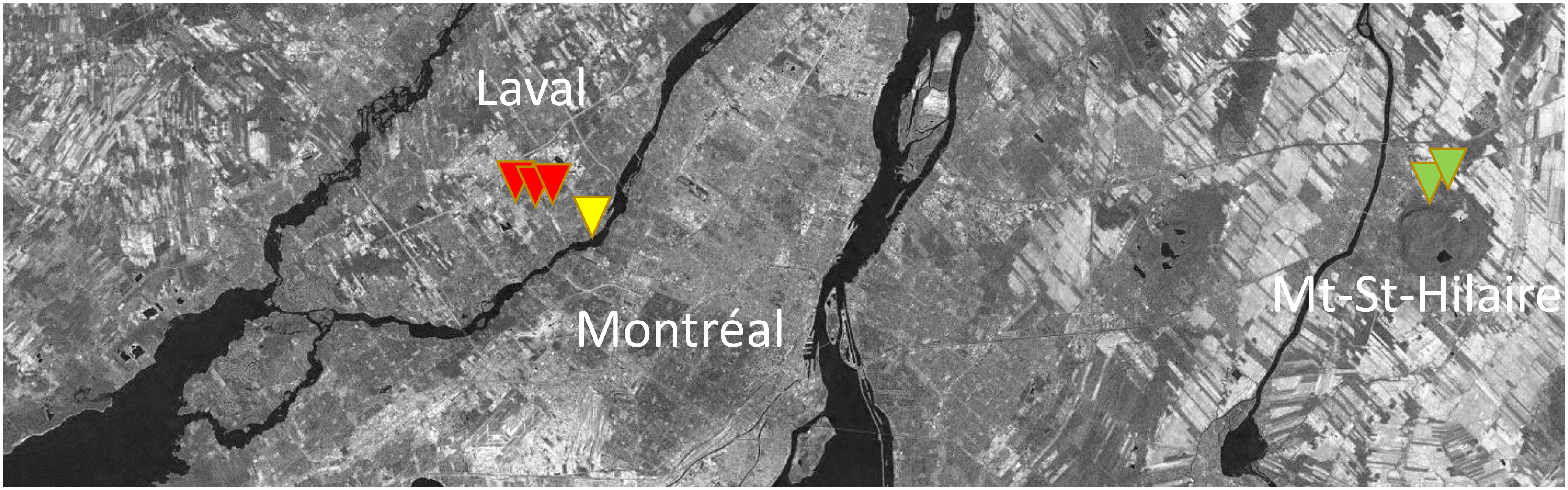
6 sites – 16 bioretention cells

- > Centropolis Phase1 (Laval)
- > Centropolis Phase2 (Laval)
- > Saint-Martin Blvd (Laval)
- > GRL office (Laval)
- > City Hall Parking (Mont-Saint-Hilaire)
- > Blain Street (Mont-Saint-Hilaire)



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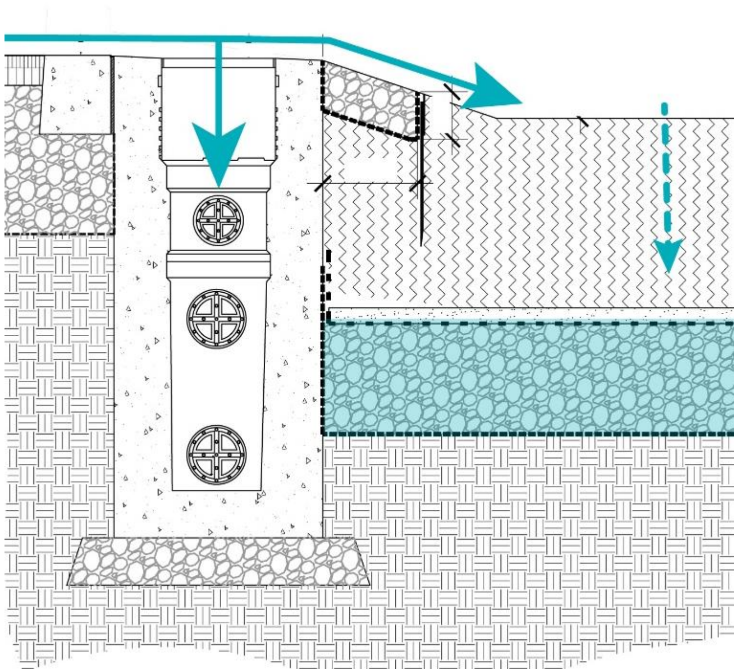
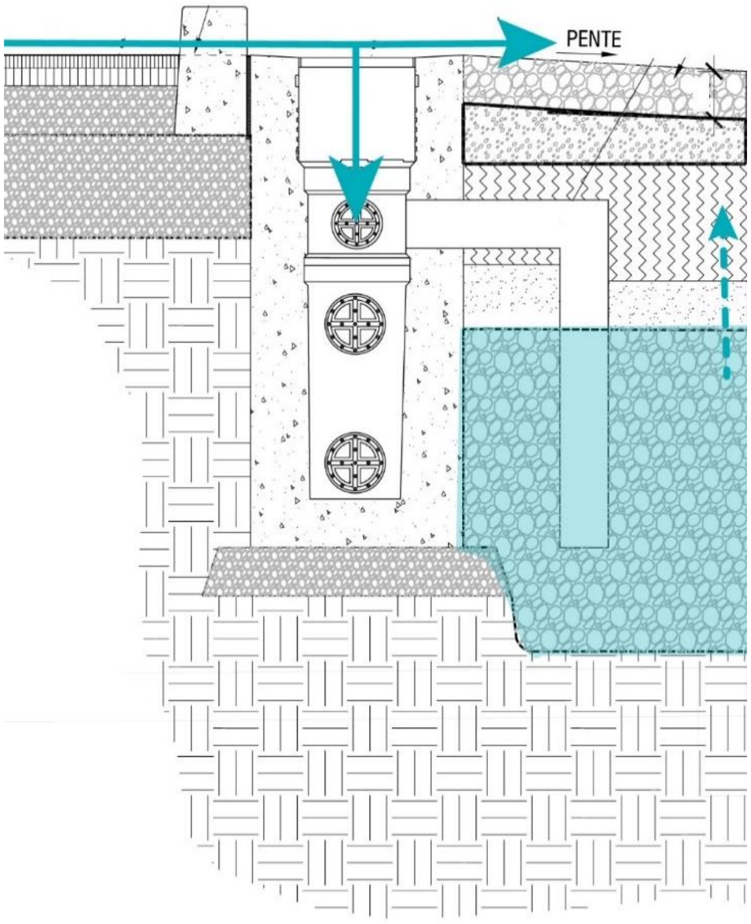
Design options

Infiltration



> Media
> Seperation layer
> Reservoir layer
> Vegetation

Exfiltration



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Media options

> Organic matter
> Wilting point
> Field capacity

Growing Media	Permanent wilting point (theoretical) PWP	Field capacity (theoretical) FC
House mix A	12%	25-34%
House mix B	12%	25-34%
no 2 Savaria	12%	24%
Écovert/Natureausol Savaria	10%	21.5%

Laval projects

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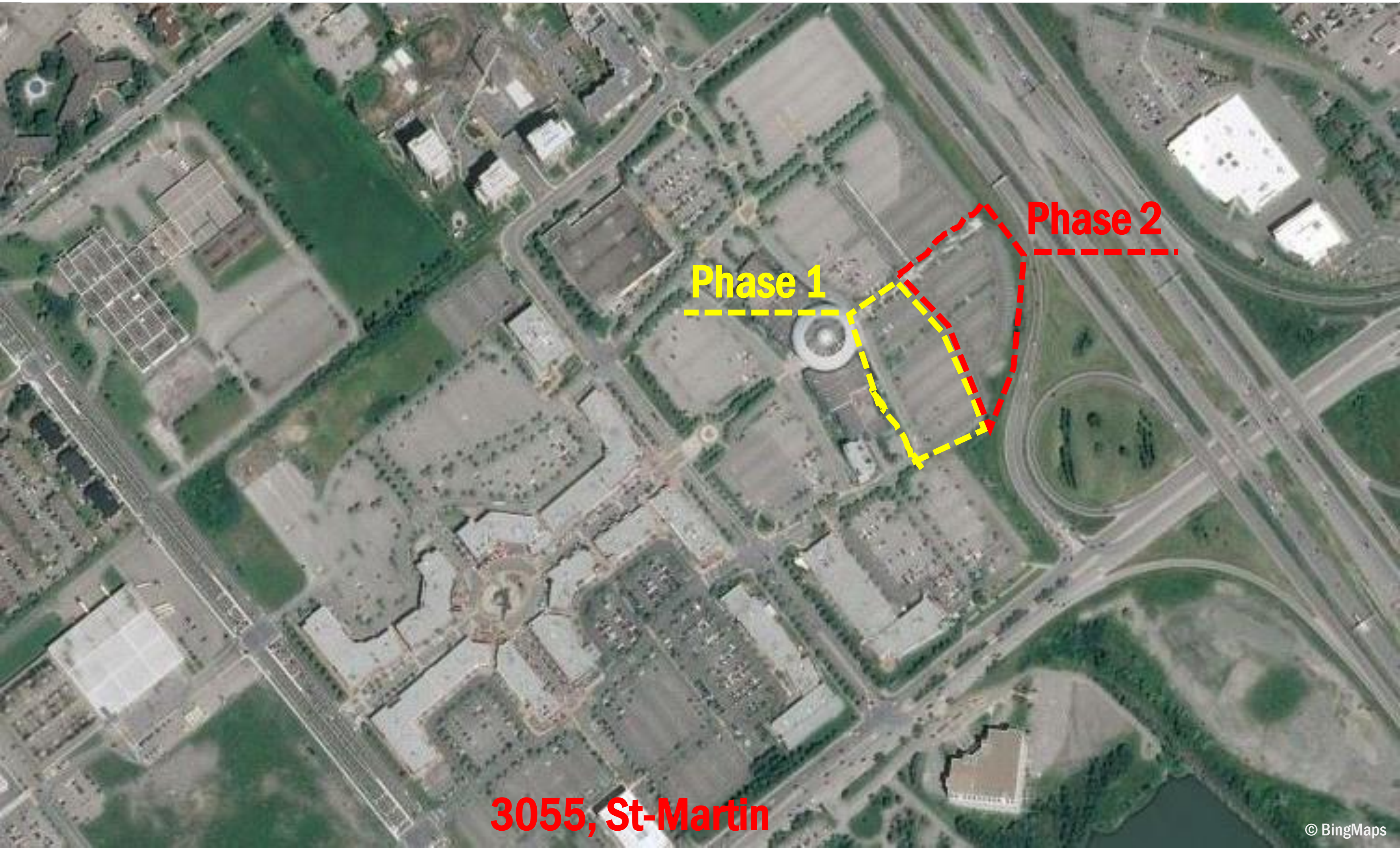
Centropolis



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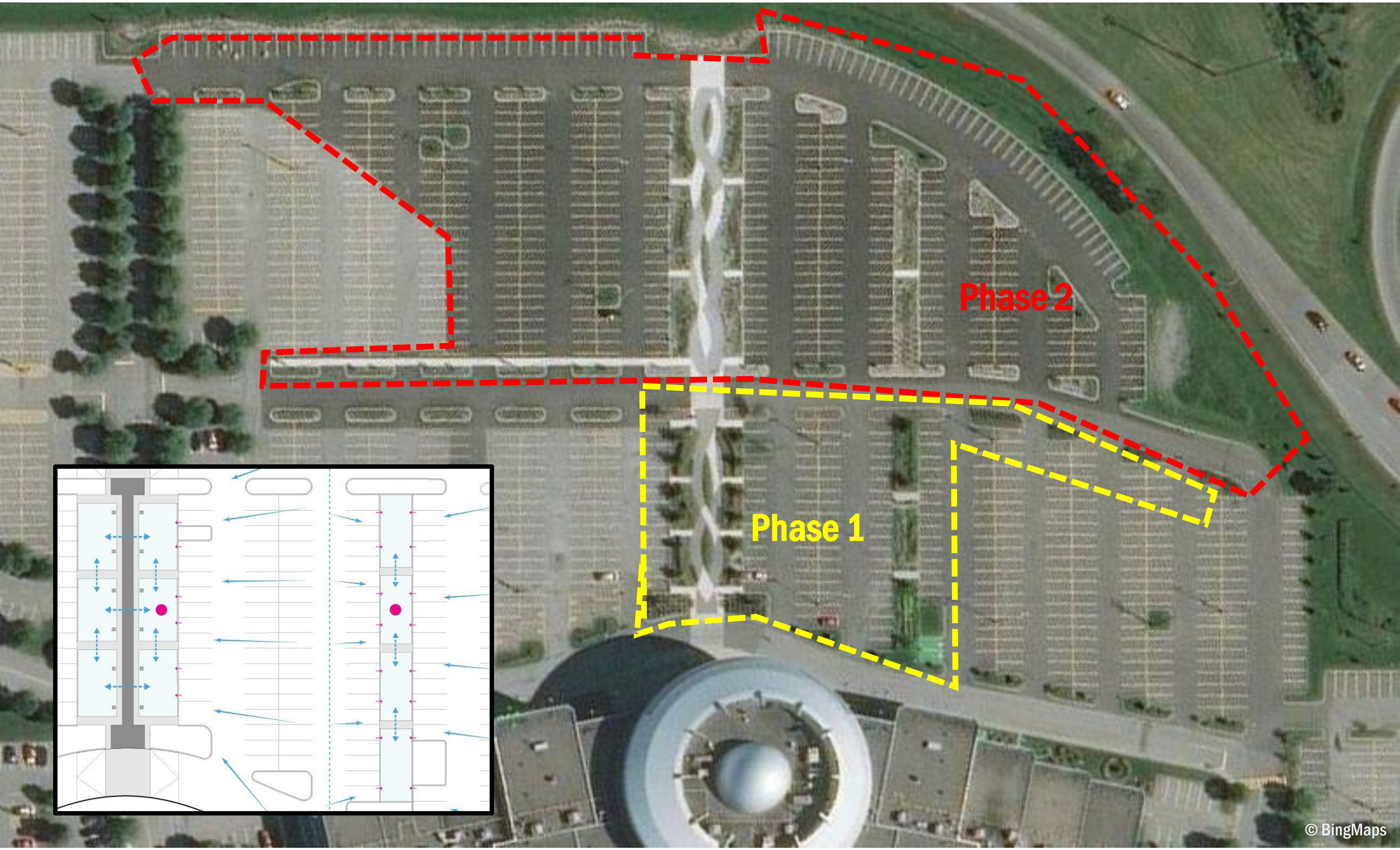
Centropolis



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Centropolis (phase 1)

> Year of Construction : 2012

> Vegetation type : Trees, shrubs and forbs

> 2 of the 9 bioretention cells were followed

Inlet type	Exfiltration
Media	No 2 Savaria
Number of PWP events	8
Number of FC events	1
Plant health	80% -90%

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Centropolis (phase 2)

- Year of Construction : 2014/2015
- Vegetation type : Trees, shrubs and forbs
- 5 of the 8 bioretention cells were followed

Inlet type	Infiltration
Media	Ecovert/Natureausol
Number of PWP events	1
Number of FC events	2
Plant health	85%-90%

3055 boulevard St-Martin

- > <u>Year of Construction</u> : 2014/2015
- > <u>Vegetation type</u> : Shrubs and forbs
- > 3 of the 3 bioretention cells were followed

3055 boulevard St-Martin

> Year of Construction : 2014/2015

> Vegetation type : Shrubs and forbs

> 3 of the 3 bioretention cells were followed

Inlet type	Infiltration and exfiltration
Media	Ecovert/Natureausol
Number of PWP events	2/1
Number of FC events	1/1
Plant health	90%

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GRL Office

- > Year of Construction : 2009
- > Vegetation type : Forbs
- > 2 of the 2 bioretention cells were followed

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Runoff Water Supply : Infiltration

GRL Office

- > Year of Construction : 2009
- > Vegetation type : Forbs
- > 2 of the 2 bioretention cells were followed

Inlet type	Infiltration
Media	House mix A and B
Number of PWP events	A: 7 B: 14
Number of FC events	A: 2 B: 2
Plant health	90%

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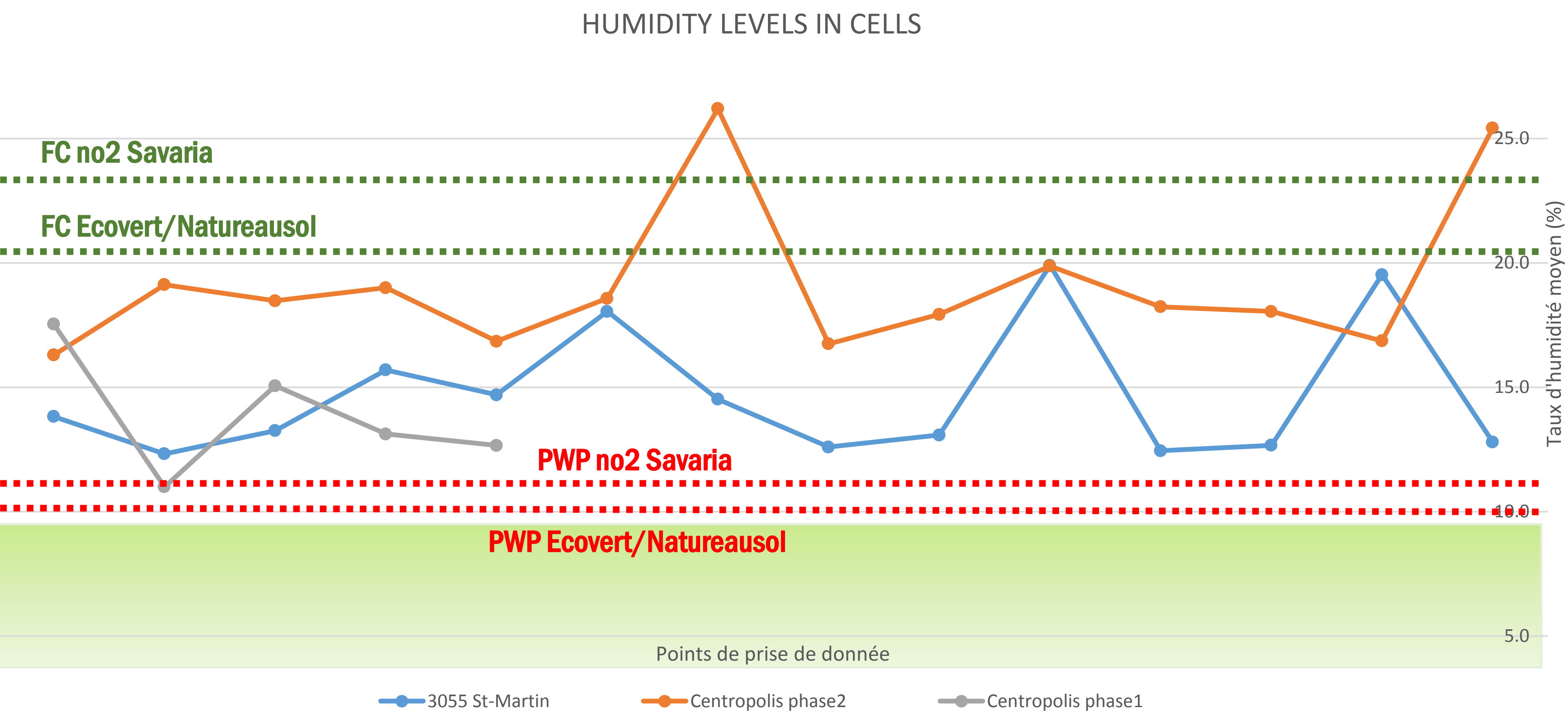
Centropolis Comparative Results



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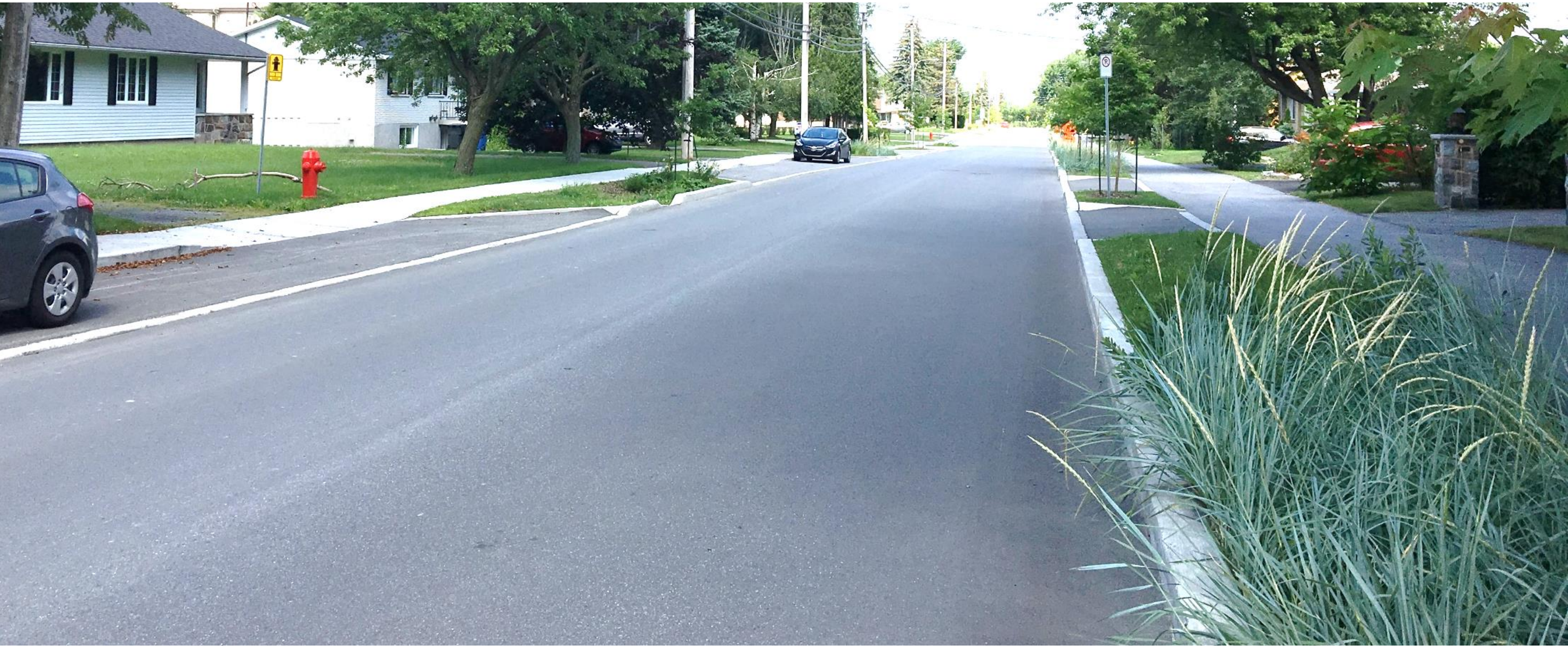
Mont-Saint-Hilaire projects



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Blain Street

Groupe ROUSSEAU LEFEBVRE

Blain Street

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Blain Street

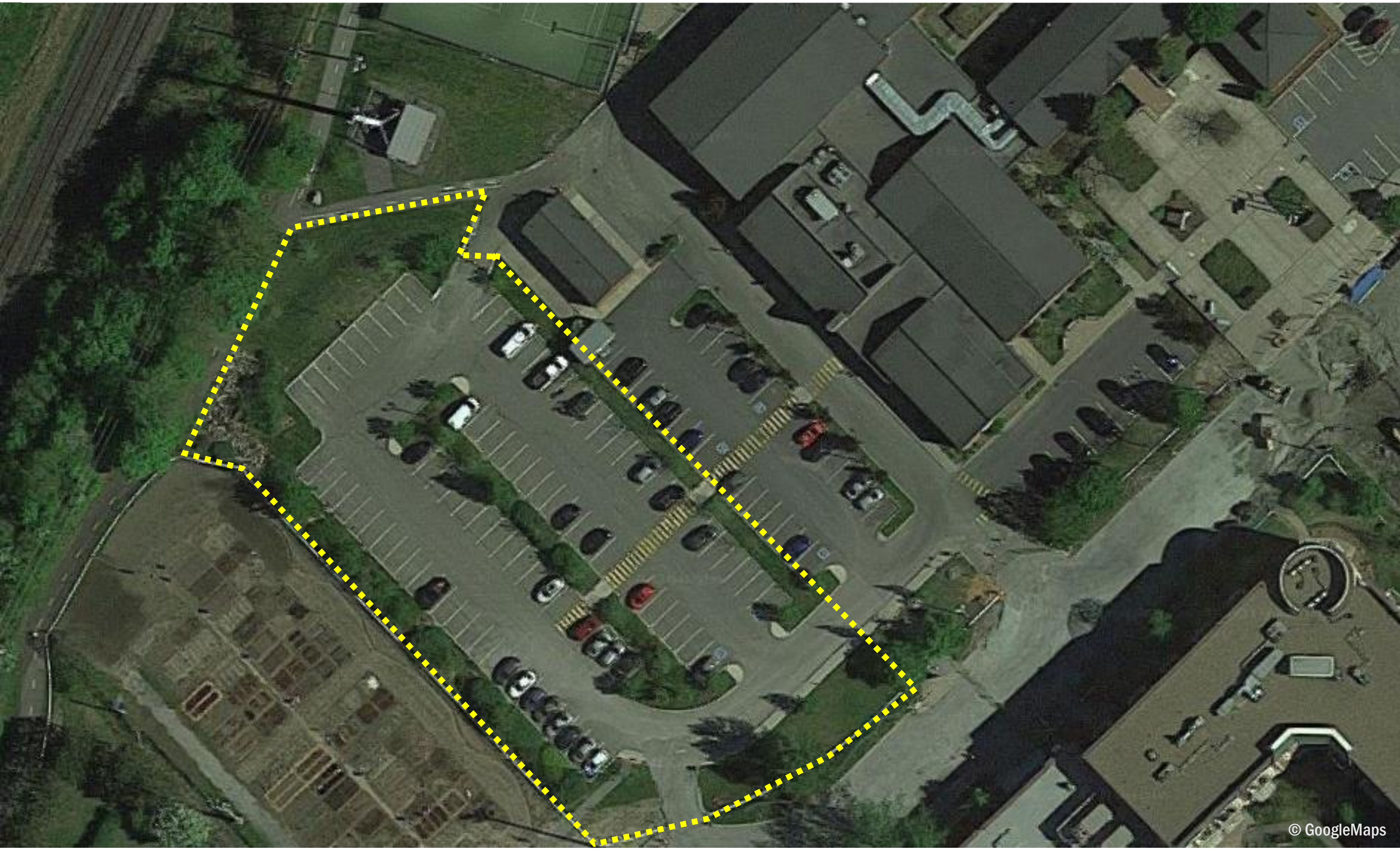
> <u>Year of Construction</u> : 2015

> <u>Vegetation type</u> : Trees, shrubs and forbs

> <u>5 out of 15 cells followed</u>

Inlet type	Infiltration
Media	Ecovert/Natureausol
Number of PWP events	2
Number of FC events	2
Plant health	90%

Civic Centre Mont-Saint-Hilaire



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Civic Centre

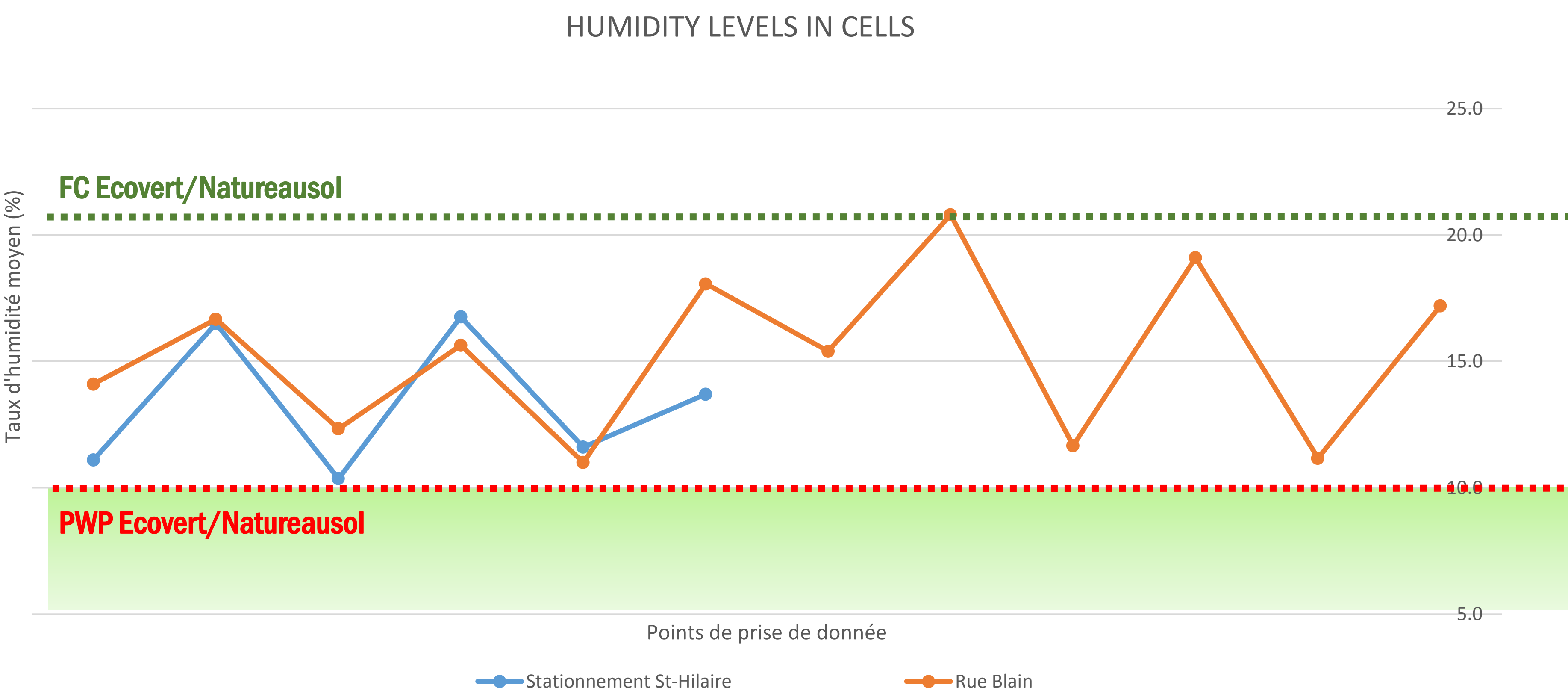
> Year of Construction : 2009

> Vegetation type : Trees, shrubs and forbs

> 3 of the 4 cells followed

Inlet type	Infiltration
Media	Écovert/Natureausol
Number of PWP events	6
Number of FC events	1
Plant health	100%

MSH Comparative Results



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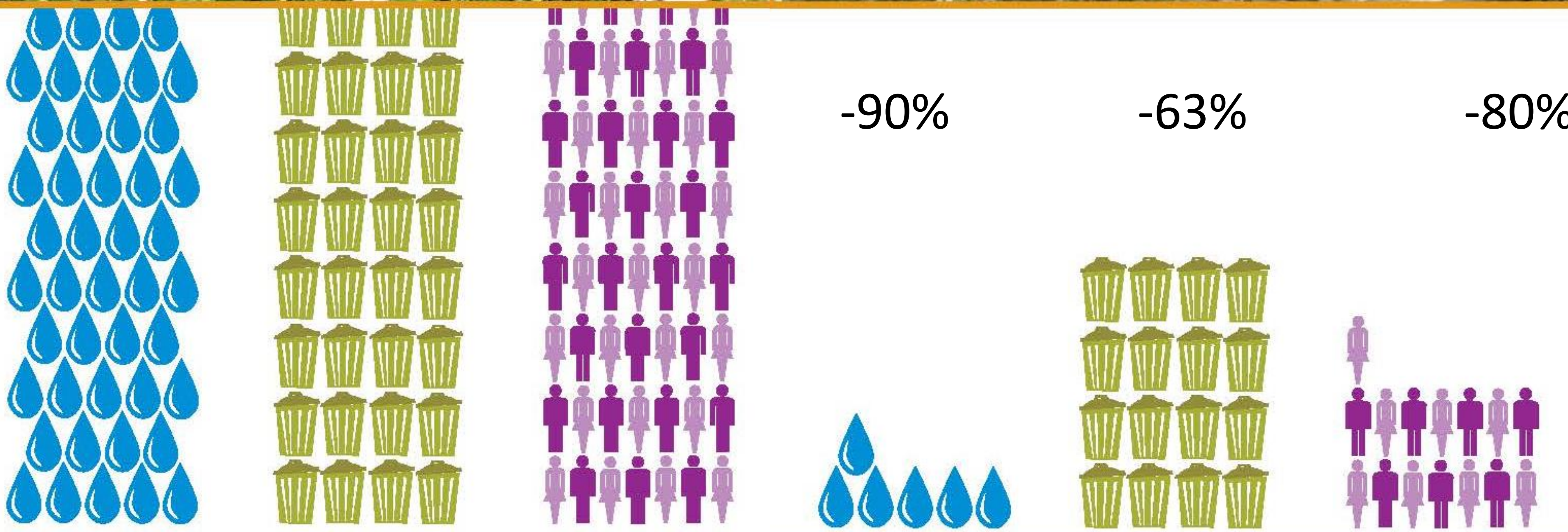
Plant maintenance

Plant maintenance

Traditional

Sustainable



Source: City of Santa Monica:

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Sediment control/pretreatment

Source: GRL

Source: GRL

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What we learned

- > Infiltration systems distribute water more evenly over time
- > Inlet design is key
- > Lowest wilting point (PWP) seem to lead to greater performance of vegetation
- > Sediment loads/maintenance have to be monitered to increase performance

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A reminder

> Media choice is one of the many parameters… it is a system!

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Thank you!

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Bioretention Soil Media:
A Phosphorus Source or Sink?

TRIECA Conference

March 21st, 2018

Brett H. Emmons, CEO
Principal & Founder, EOR
bemmons@eorinc.com
www.eorinc.com

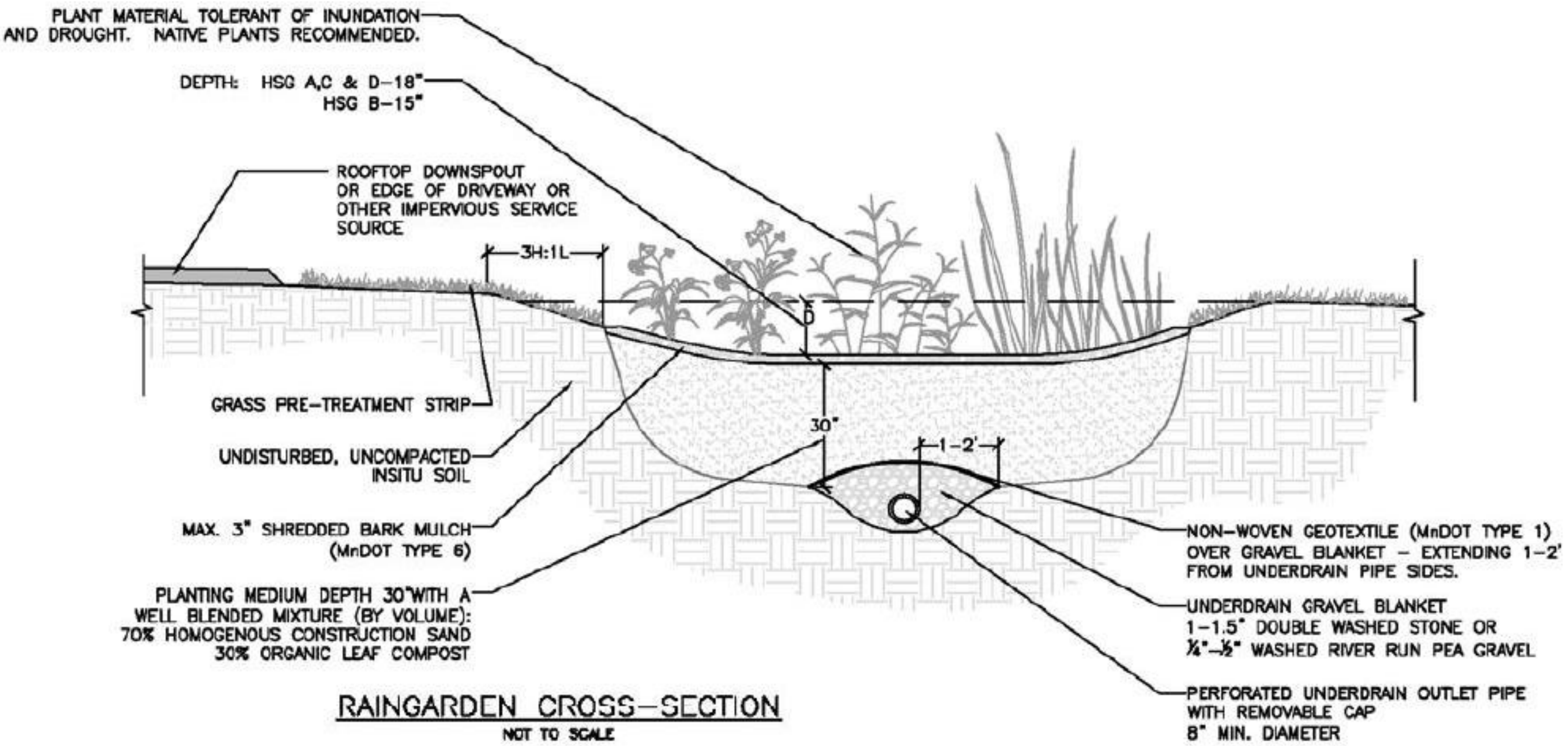
Introductions

watersheds & **water resources**

e**cosystem restoration**

civil engineering & landscape arch.

Bioretention Media Composition



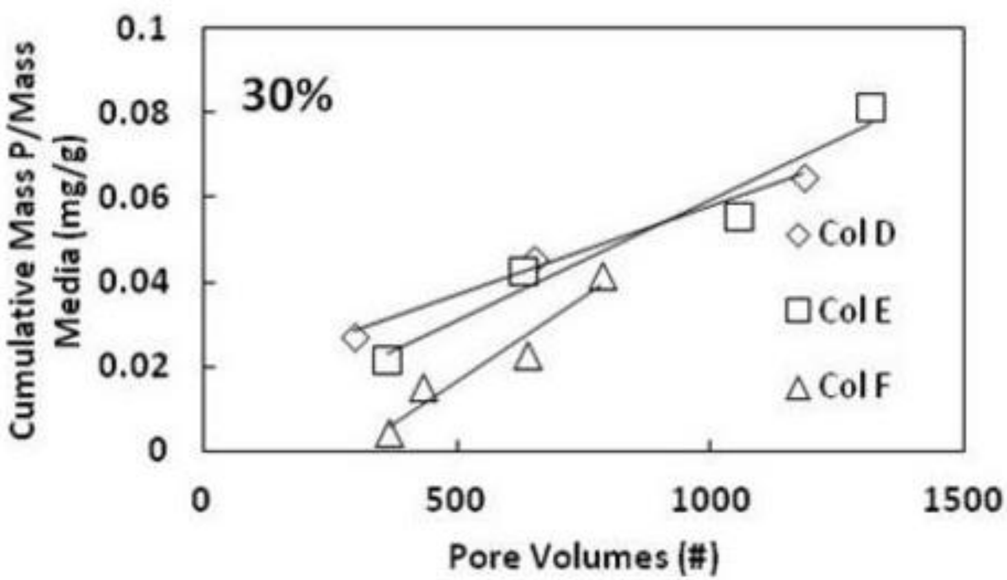
MN Mix A: Water Quality Blend

A well blended, homogenous mixture of:
- 60 to 70 percent construction sand;
- 15 to 25 percent top soil; and
- 15 to 25 percent organic matter

MN Mix B: Enhanced Filtration Blend

A well-blended, homogenous mixture of:
- 70 to 85 percent construction sand; and
- 15 to 30 percent organic matter

UMN Research: P-leaching



UMN Stormwater Research Updates Capture and Release of Pollutants by Rain Gardens
November 2011 (volume 6 - issue 10)
Contributed by Joel G. Morgan,
John S. Gulliver, and Raymond M. Hozalski
(Department of Civil Engineering, Univ. of MN)

The column studies indicate that phosphorus leaches off the compost and leaves the system.

- Phosphorus leaching rate of 0.29 mg/L from 30% compost columns likely to remain constant over time because compost will continually decompose.

- Plants uptake phosphorus while alive; however, upon death, release it back into the soil media.

- Annual refreshing of the top layer of mulch continues to add a phosphorus source.

Phosphorus-Index

Page 1 of 1

Report Number: 17-138-0533

Account Number: 40751

Send To: Turf & Soil Diagnostics - NY
35 King Street
Trumansburg NY 14886

Waypoint ANALYTICAL

"Every acre...E

If the media phosphorus content exceeds 30 mg-P/kg-mix (ppm) it is likely to export Phosphorus

SOIL ANALYSIS REPORT

Analytical Method(s): Mehlich 3 SMP Buffer pH Loss On Ignition Water pH

Date Received: 05/18/2017 Date Of Analysis: 05/19/2017 Date Of Report: 05/25/2017

Sample ID Field ID	Lab Number	OM % Rate	W/V Soil Class	ENR lbs/A	Phosphorus M3 ppm	Phosphorus M3 Rate	Phosphorus ppm	Phosphorus Rate	Phosphorus ppm	Phosphorus Rate	Potassium K ppm	Potassium K Rate	Magnesium Mg ppm	Magnesium Mg Rate	Calcium Ca ppm	Calcium Ca Rate	Sodium Na ppm	Sodium Na Rate	pH Soil pH	pH Buffer Index	Acidity H meq/100g	C.E.C meq/100g
70/30 Rain w/ Compost	25875	1.0 L		43	70	H					310	VH	177	M	1775	H	46	VL				11.3
80/20 Rain w/ Compost	25876	0.8 VL		42	44	M					170	VH	155	M	1405	H	43	L				8.9
70/30 Rain w/ 1inch Peat	25877	2.2 L		65	2	VL					28	VL	158	M	1321	H	36	VL				8.9
80/20 Rain w/ 1inch Peat	25878	1.3 L		54	2	VL					52	VL	121	H	987	H	30	L				6.2

Sample ID Field ID	Percent Base Saturation K %	Mg %	Ca %	Na %	H %	Nitrate NO_3 N ppm	Nitrate Rate	Sulfur S ppm	Sulfur Rate	Zinc Zn ppm	Zinc Rate	Manganese Mn ppm	Manganese Rate	Iron Fe ppm	Iron Rate	Copper Cu ppm	Copper Rate	Boron B ppm	Boron Rate	Soluble Salts SS ms/cm	Soluble Salts Rate	Total Phosphorus as P %	
70/30 Rain w/ Compost	7.0	13.1	78.5	1.8	0.0			15	L	3.2	M	26	H	95	VH	0.7	L	0.8	M				
80/20 Rain w/ Compost	4.9	14.5	78.9	2.1	0.0			14	L	2.5	M	23	H	89	VH	0.6	L	0.6	M				
70/30 Rain w/ 1inch Peat	0.8	14.8	74.2	1.8	9.0			7	VL	0.8	VL	18	M	87	VH	0.5	L	0.1	VL				
80/20 Rain w/ 1inch Peat	2.2	16.3	79.6	2.1	0.0			5	VL	0.7	VL	16	M	73	VH	0.5	L	0.1	VL				

Material Specification & Testing

1. Media P-Index. Revised specification limit between 10 and 30 ppm when using the Mehlich-3 test and submittal of test results [*to review agency*] at least 2-weeks prior to delivery and construction, or

2. Substitution of peat moss for a portion of the compost to reduce the overall P-index to within the range specified above, or

3. Amendment of the media to enhance phosphorus sorption.

Testing Requirements

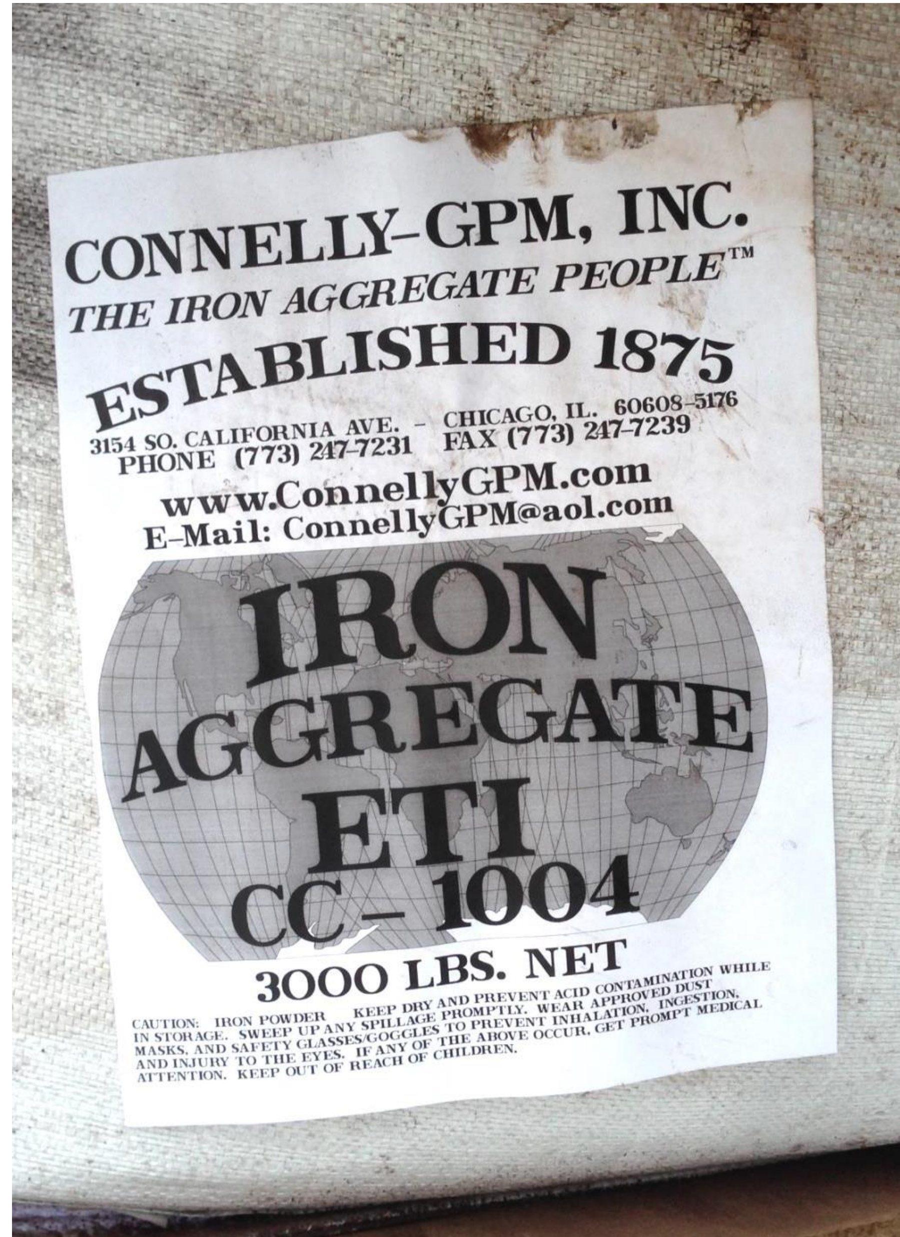
Soil media test results and a soil sample must be submitted at least 14 days prior to material delivery.

Analysis	($)	Standard Turnaround Time	Sample Amount Needed
9045 pH Soil	21	4 Hours	50 grams
ASTM D2974 Organic Matter	42	2 Days	50 grams
Phosphorous	75	2 Days	60 grams
365.1 Total Phosphorous	32	2 Days	20 grams
CEC	93	3 Days	200 grams
Grain Size	177	5 Days	200 grams

Design Variants – 80/10/10 Mix

Design Variants – Iron Enhanced Sand

95% ASTM C-33
Coarse Wash Sand
and 5% Iron Aggregate
by weight (Connelly GPM Inc.,
ETI CC 1004 or approved equal).



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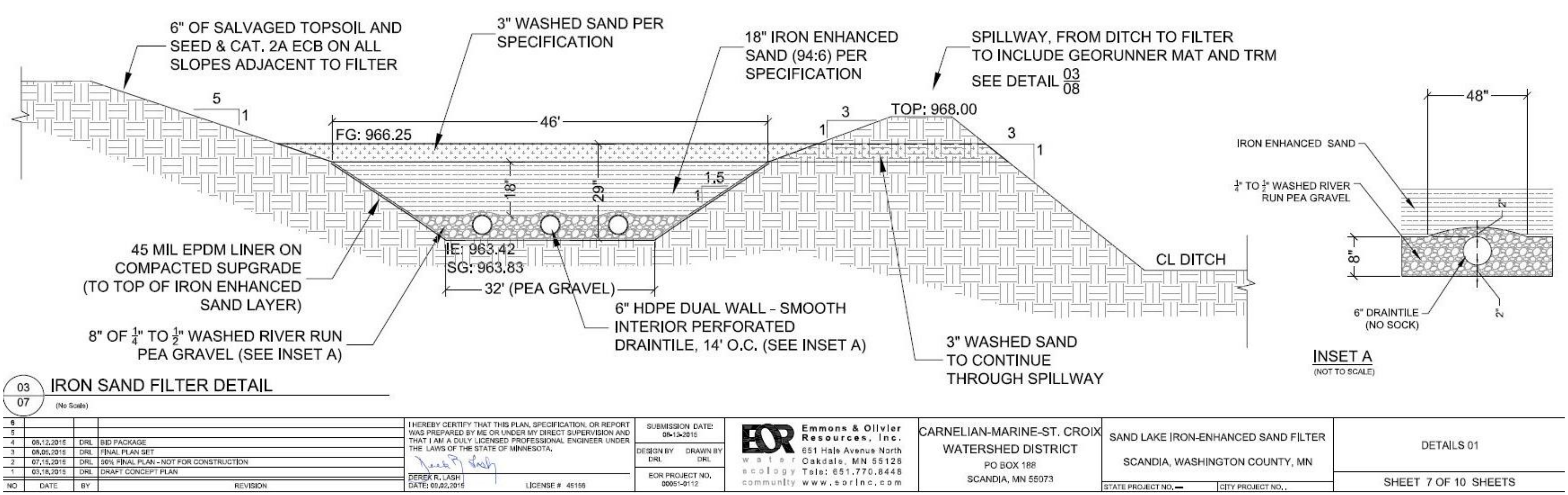
THE IRON AGGREGATE PEOPLE™

THE SOURCE TO HELP YOU IRON THINGS OUT

Design Variants – Iron Enhanced Sand

Typical cross section
(top to bottom):

- 3-inches sand
- 18-inches iron-enhanced sand
- 8-inches pea gravel with perforated draintile
- 45 Mil EPDM liner



Design Variants – Iron Enhanced Sand

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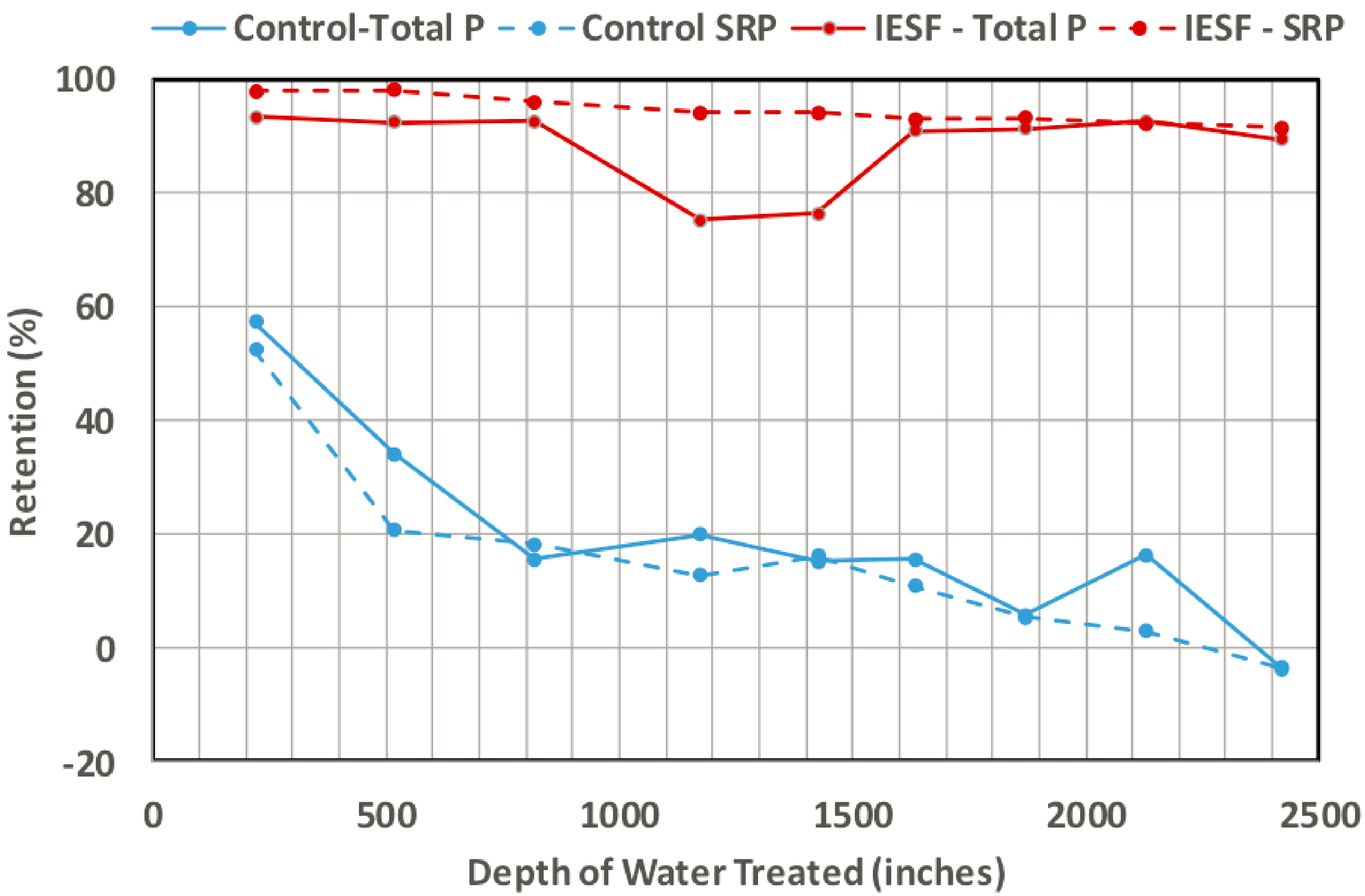
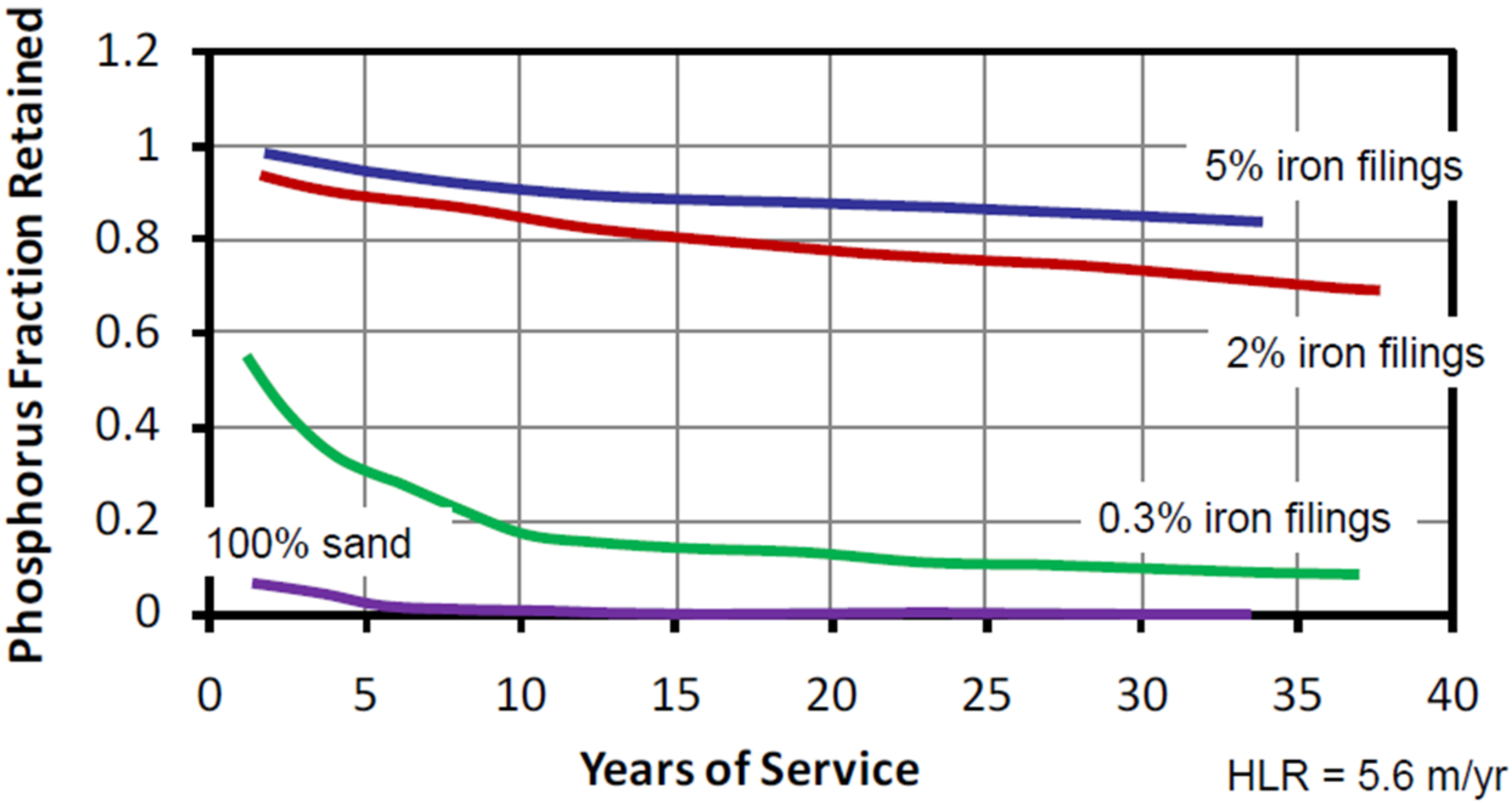


Weiss, P., Aljobeh, Z., Bradford, C., and Breitzke, E. (2016) An Iron-Enhanced Rain Garden for Dissolved Phosphorus Removal. World Environmental and Water Resources Congress 2016: pp. 185-194. doi: 10.1061/9780784479889.020

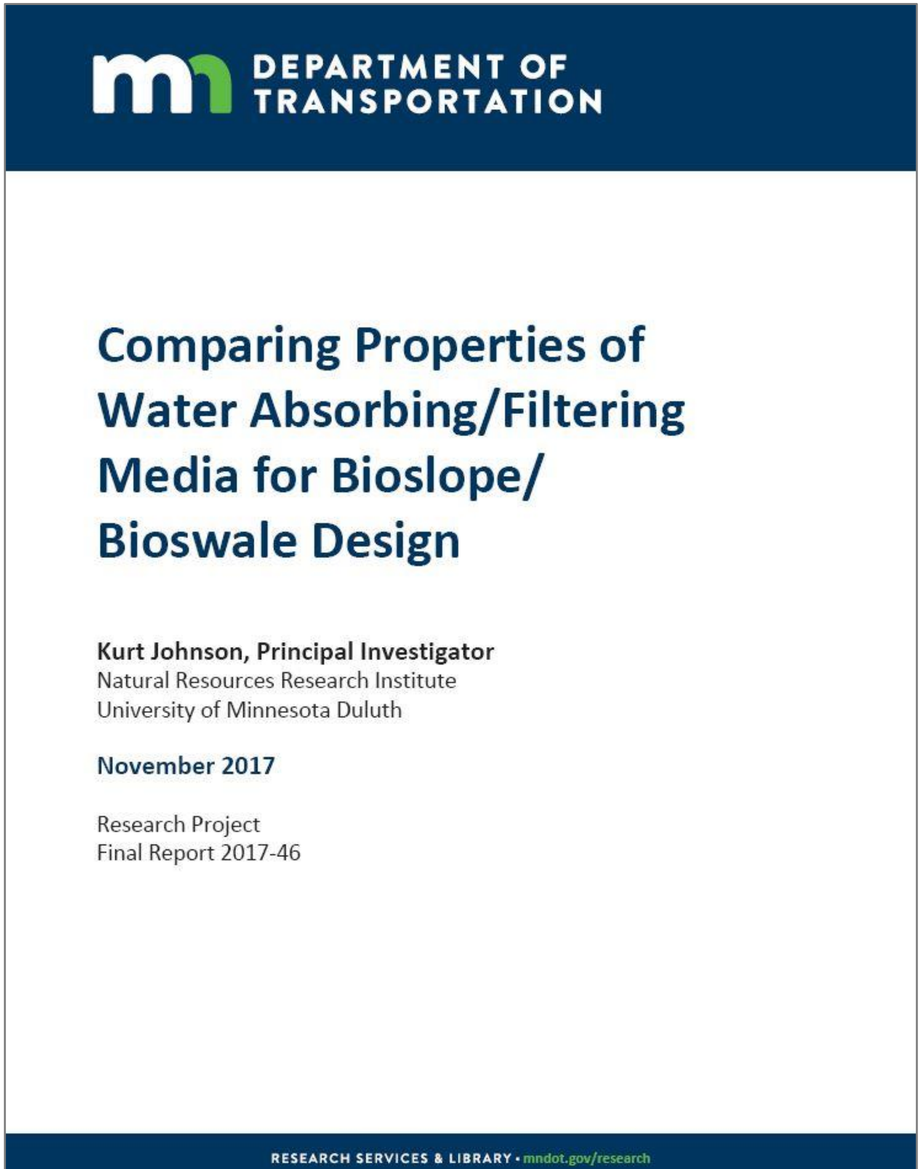
Design Variants – Iron Enhanced Sand



Erickson, A.J., J.S. Gulliver, and P.T. Weiss. 2007. "Enhanced sand filtration for storm water phosphorus removal, Journal of Environmental Engineering." 133 (5): 485-497.

Erickson, A.J., J.S. Gulliver, and P. T. Weiss. 2012. “Capturing Phosphates with Iron Enhanced Sand Filtration,” Water Research, 46(9), 3032–3042.

Design Variants – Taconite Tailings?



DEPARTMENT OF TRANSPORTATION

Comparing Properties of Water Absorbing/Filtering Media for Bioslope/ Bioswale Design

Kurt Johnson, Principal Investigator
Natural Resources Research Institute
University of Minnesota Duluth

November 2017

Research Project
Final Report 2017-46

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Use of taconite tailings,
a waste product, looks to be a viable alternative to (expensive) iron filings for enhanced P removal.

Promising news for areas like Minnesota.

TRIECA Conference **March 21st, 2018**

Brett H. Emmons, CEO
bemmons@eorinc.com

Principal & Founder, EOR
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filtrexx CANADA SUSTAINABLE TECHNOLOGIES let nature do it:
SOLENO Mastering Storm Water
GEMS
Credit Valley Conservation inspired by nature
TITAN ENVIRONMENTAL CONTAINMENT
armtec Solutions for a Better World
York Region
Lake Simcoe Region conservation authority

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Bioretention cells under cold climate conditions

The effects of freezing and thawing on water infiltration, soil structure, and nutrient removal

Prof. Elodie Passeport

Assistant Professor, Canada Research Chair Tier II

Civil Engineering

Chemical Engineering & Applied Chemistry

UNIVERSITY OF TORONTO

Collaborations & Funding

- Funding from
  - NSERC Engage, Strategic, and CRC to E. Passeport
  - NSERC Discovery to F. Rezanezhad
  - NSERC CERC to P. Van Cappellen

- Thanks to
  - J. Douglas from J. Jenkins & Soil Construction
  - Town of Ajax
  - M. Vandergriendt, S. Legemaate, T. Milojevic, S. Dragana, Y. Li, and T. Dutta

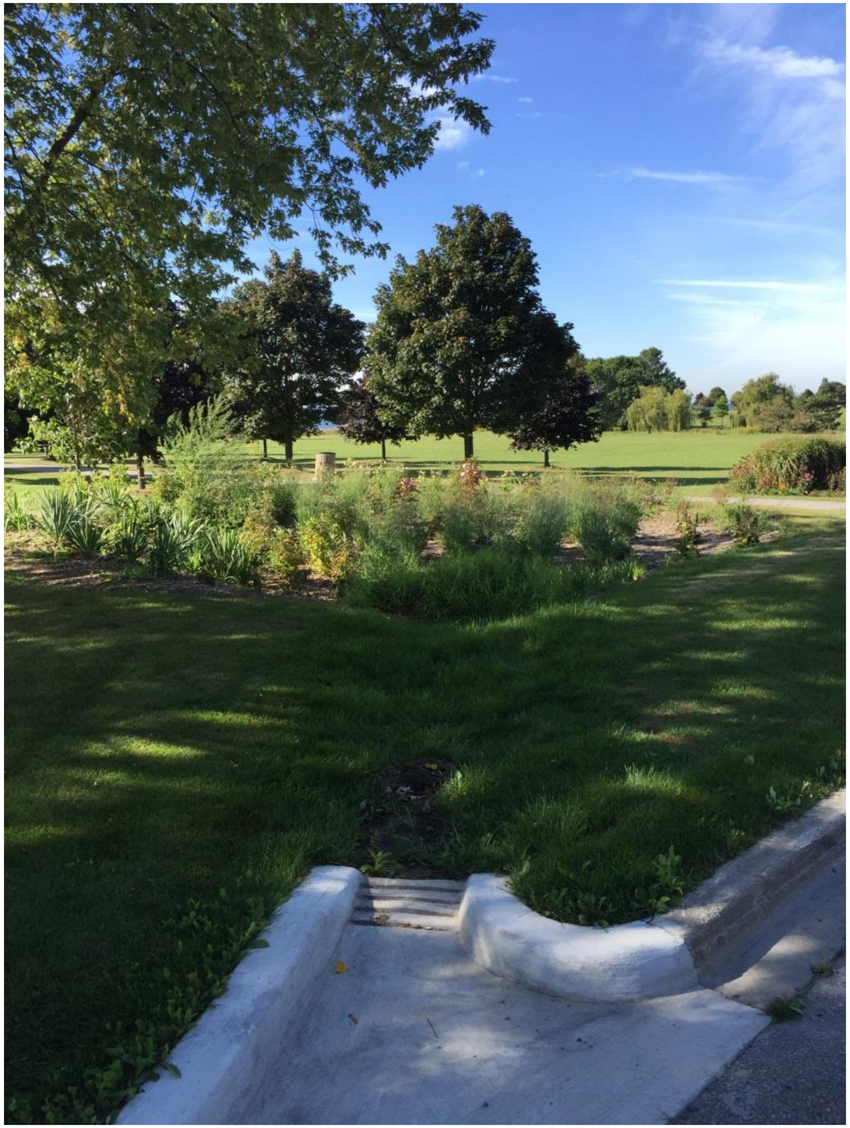
Literature Review

Bioretention cells

- Can remove N, P, TSS
- Variable efficiency
- Cold climate performance unknown
- Observed that infiltration increases upon thawing
- No definitive explanations

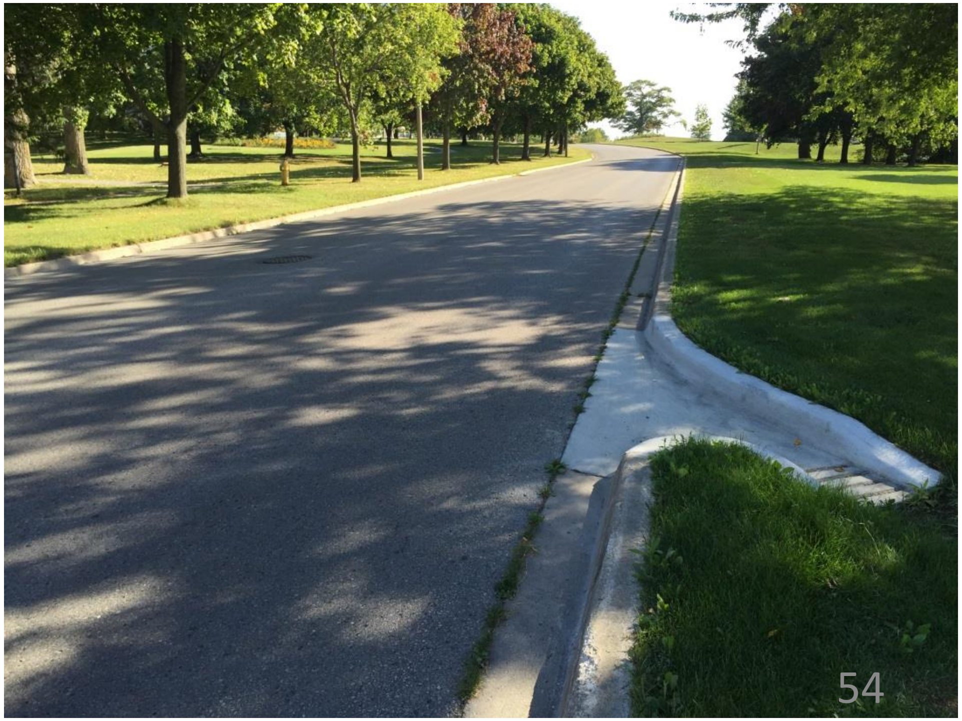
Hunt et al. 2012 *J. Environ. Eng.* 138(6); Khan et al. 2012 *Canadian J. Civil Eng.* 39(11); Denich et al. 2013 *Water Quality Research J of Canada* 48(4)

Research Objectives

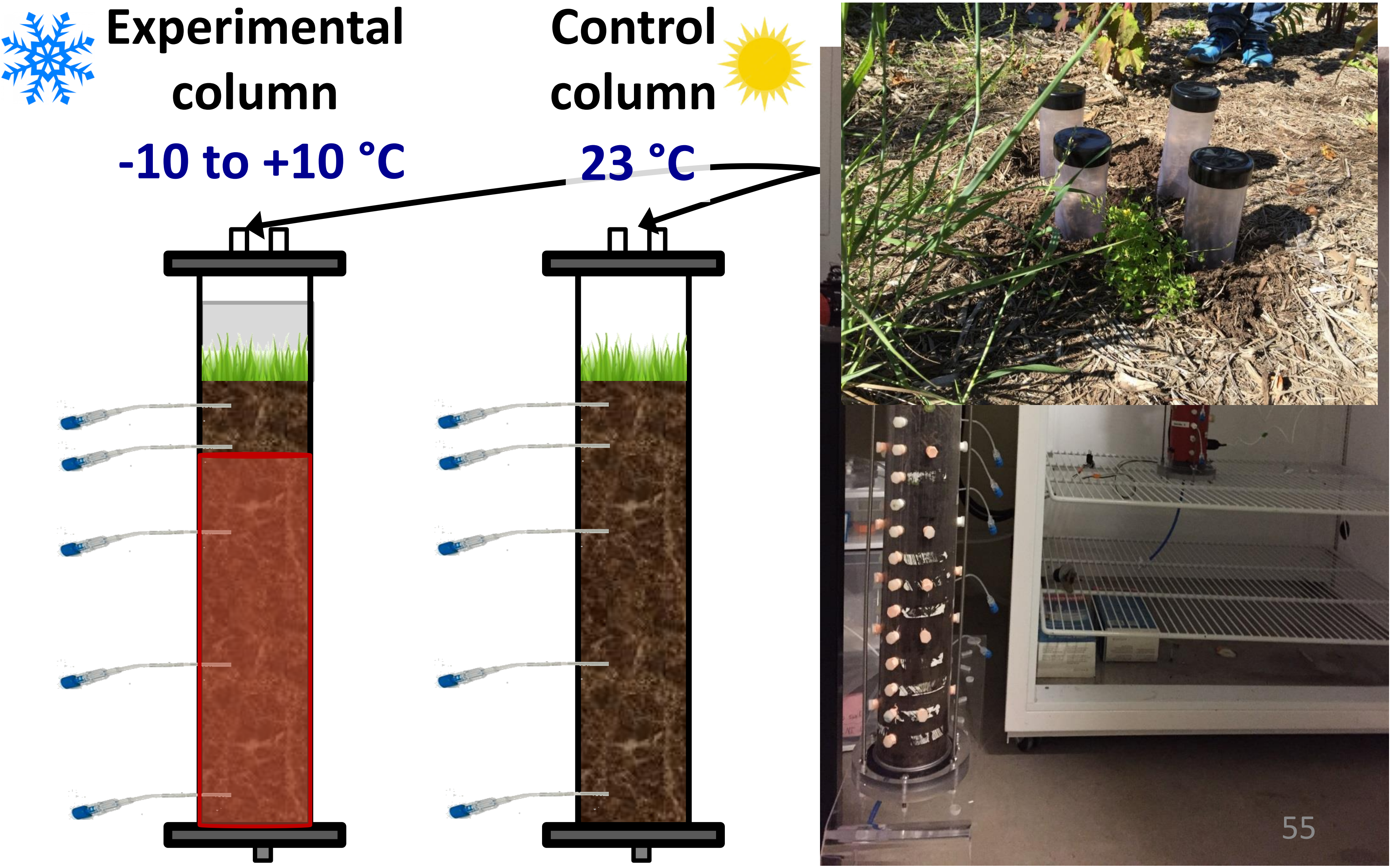


Freeze-thaw cycle effects

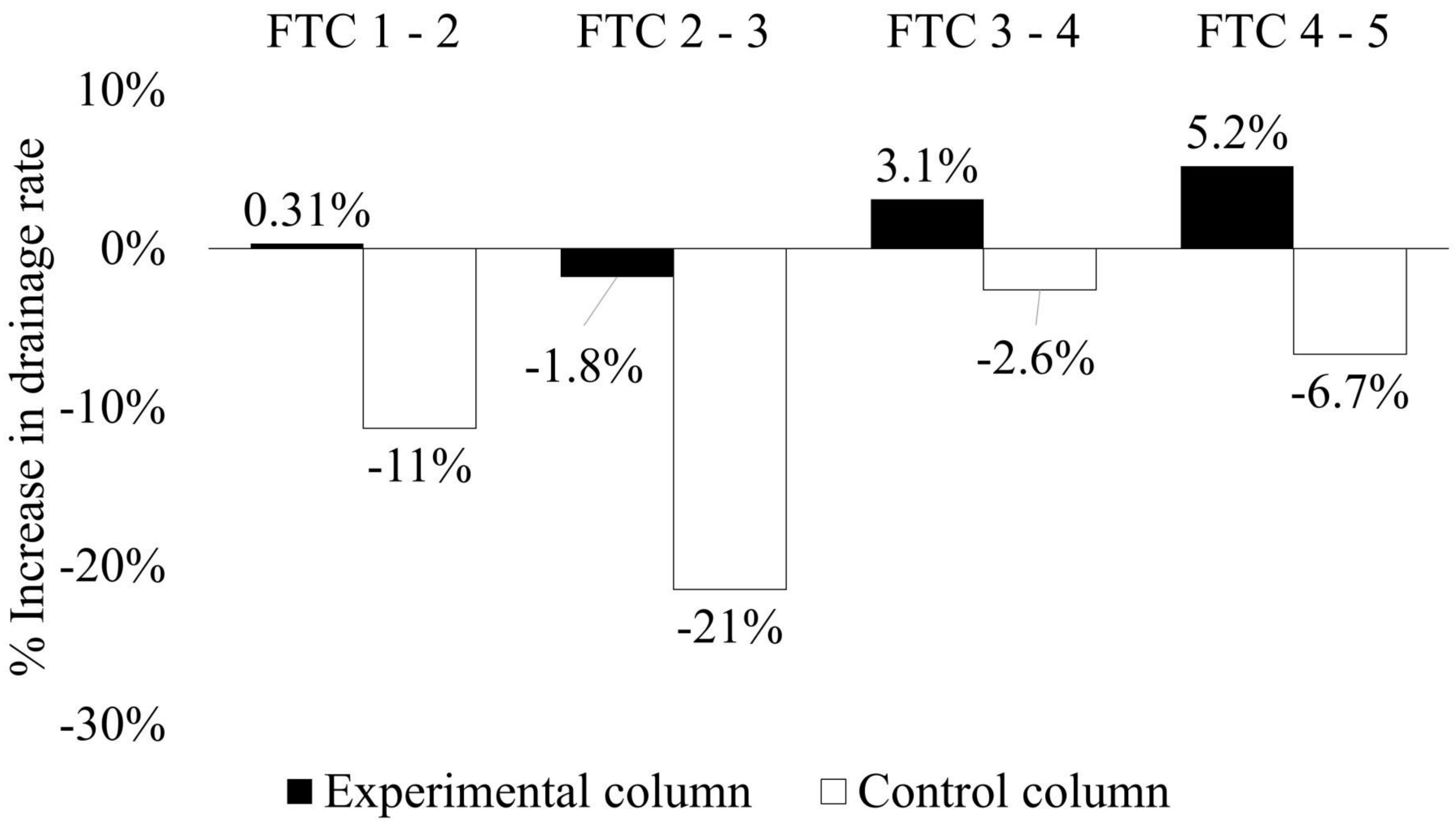
- Infiltration capacity
- Soil structure
- Nutrient removal & processes



Experimental setup



Infiltration rates

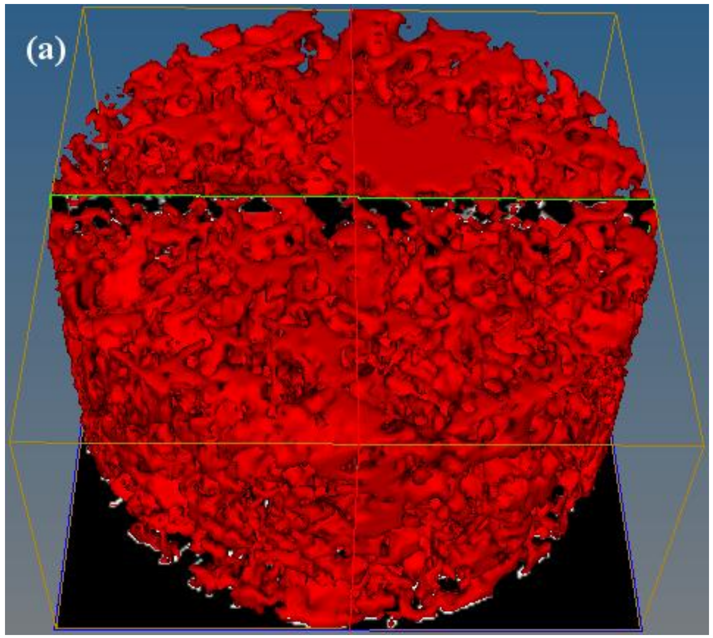


- Infiltration rates **decreased** in the **control** column (23 °C)
- Infiltration rates **increased** in the **experimental** column (FTCs)

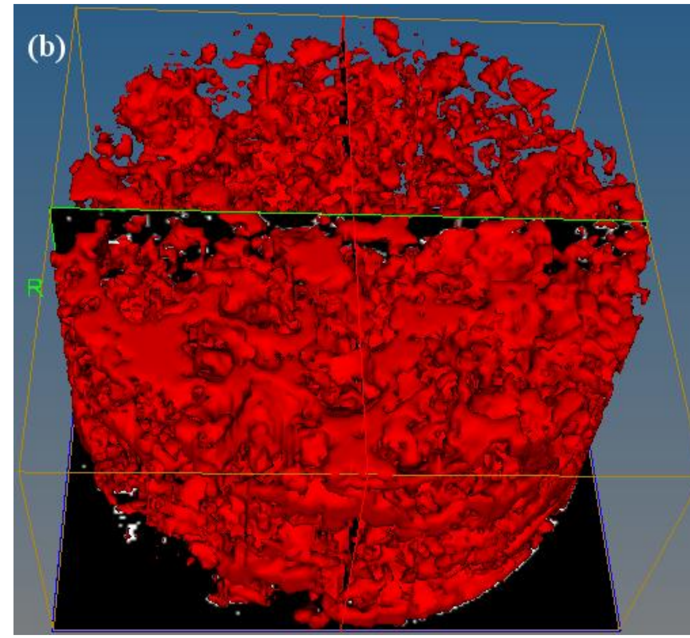
Soil structure

- Top depth samples
- After 6 experiments

Control column



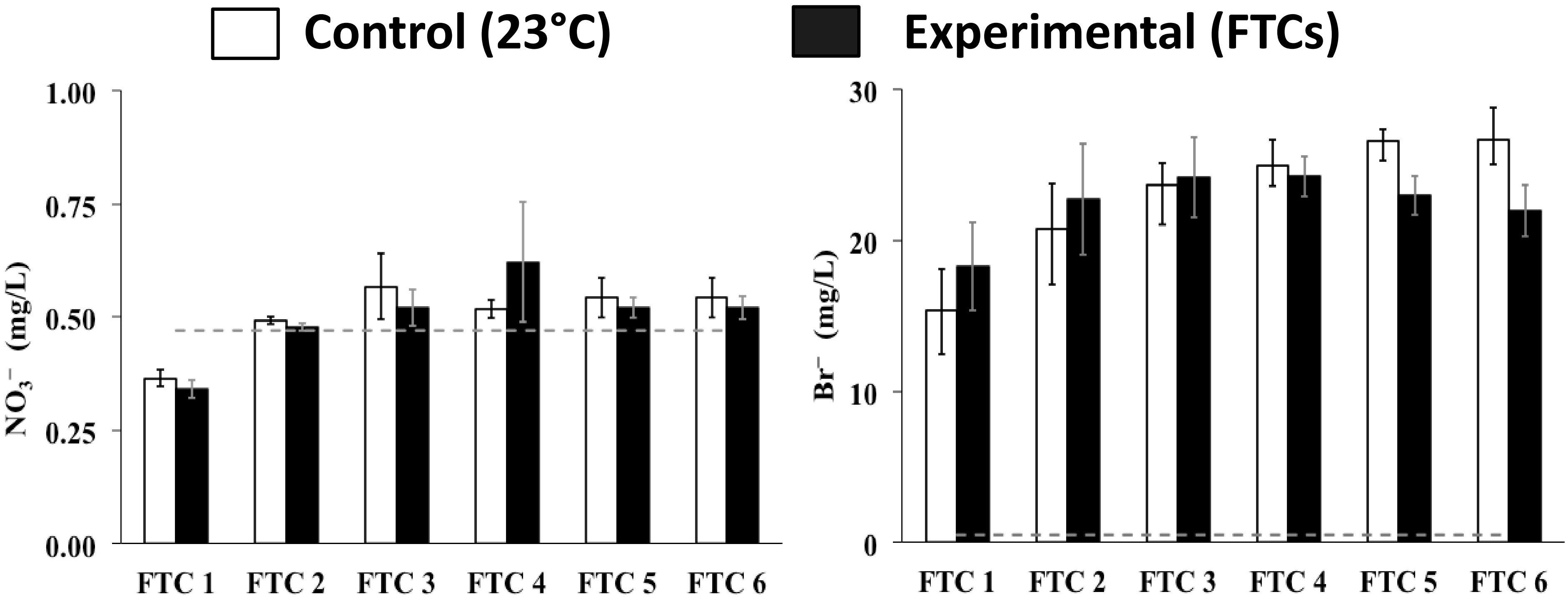
Experimental column



Pore size (μm^2)	Control		Experimental
Maximum	2.65×10^6	<	3.88×10^6
Average	1.41×10^4	<	1.76×10^4
Median	1.38×10^3	>	1.04×10^3

Nitrogen

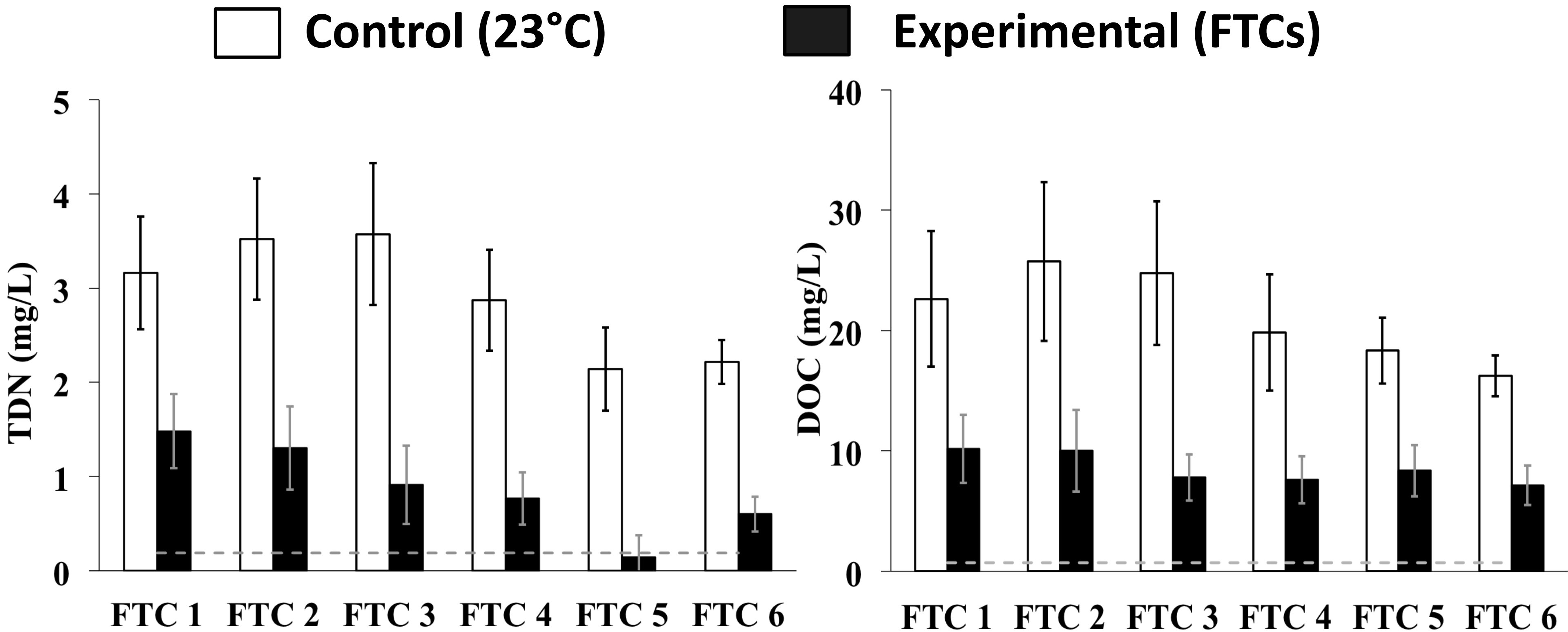
Drainage effluent chemistry



- Very low NO_3^- concentrations & lower than Br^-'s
- Further elimination processes for NO_3^- compared to Br^-

Nitrogen

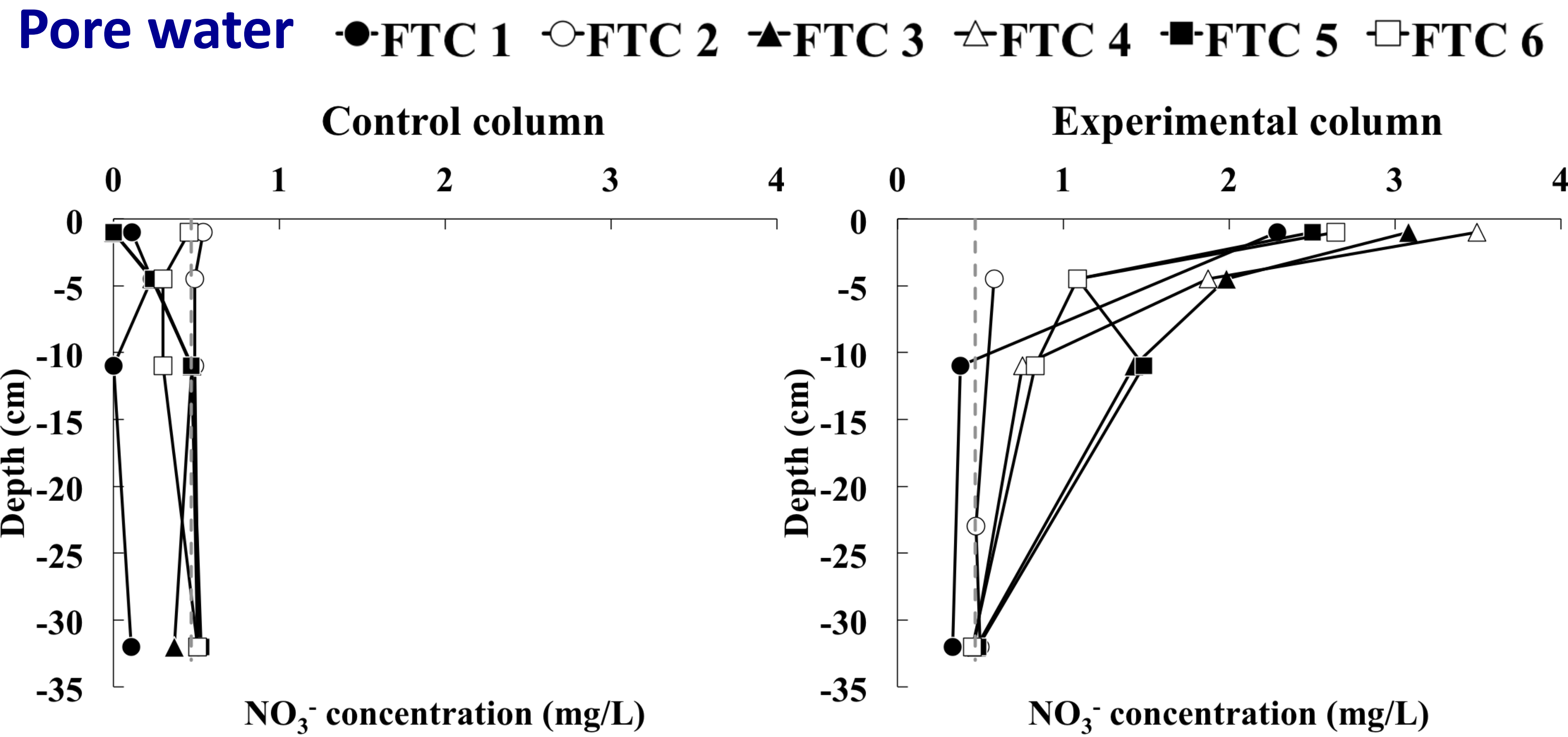
Drainage effluent chemistry



Outlet of control column:

- More TDN: more DON leaching
- More DOC: faster organic matter degradation

Nitrogen



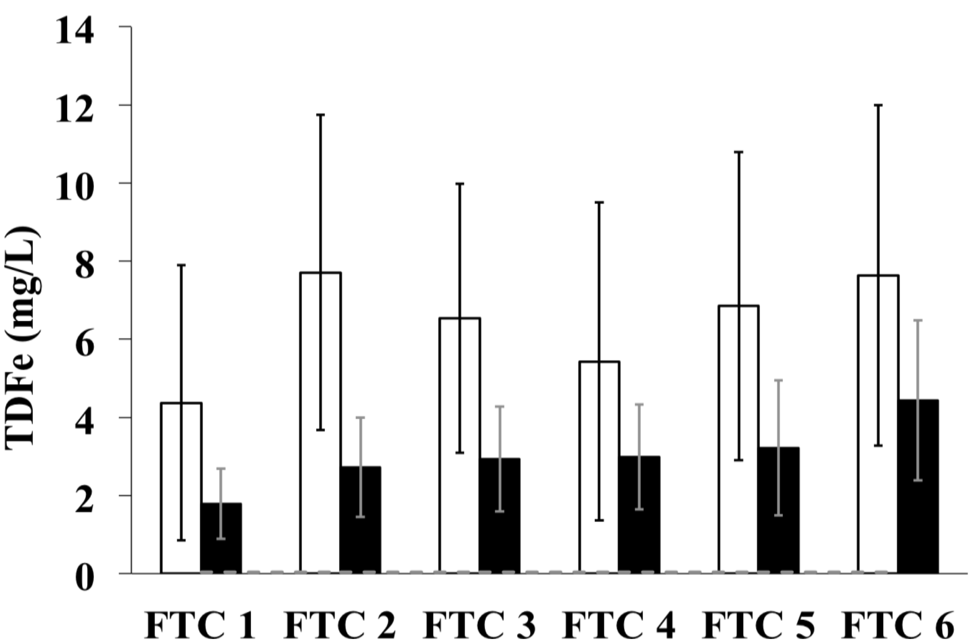
- NO_3^- concentrations below quantification in control column (23 °C)
- NO_3^- concentrations higher at top of experimental column (FTCs)
- Microbially-mediated processes in both columns

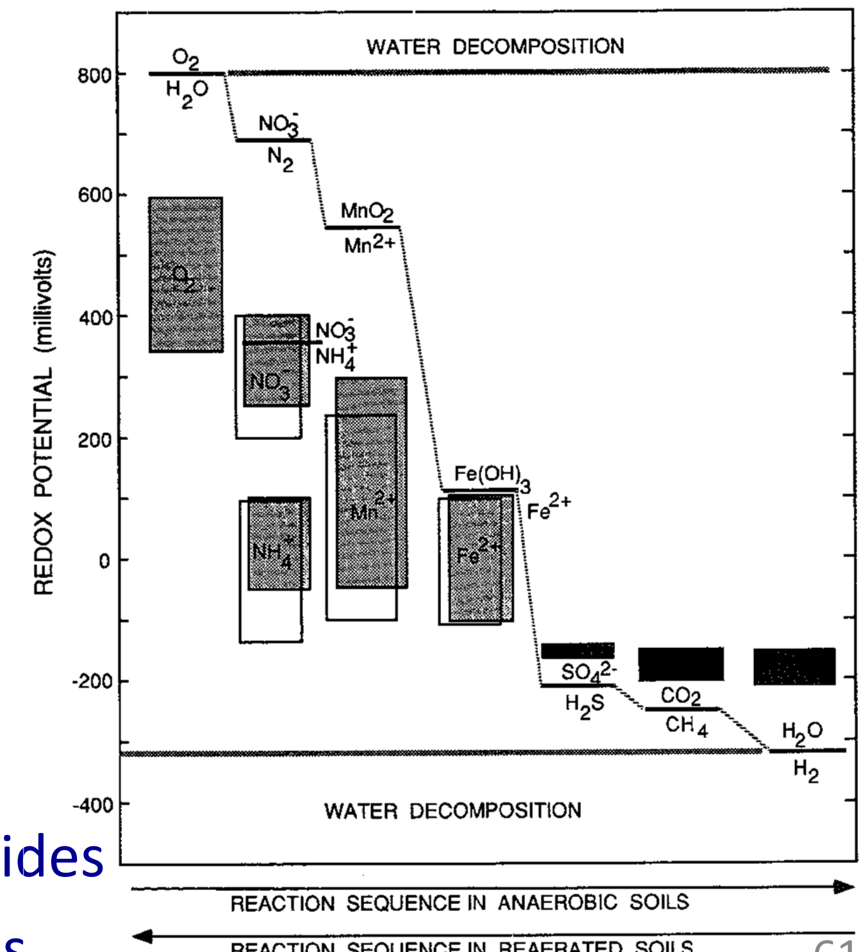
Nitrogen

Pore water -●-FTC 1 -○-FTC 2 -▲-FTC 3 -△-FTC 4 -■-FTC 5 -□-FTC 6

□ Control (23°C) ■ Experimental (FTCs)

Mc Bride, 1994

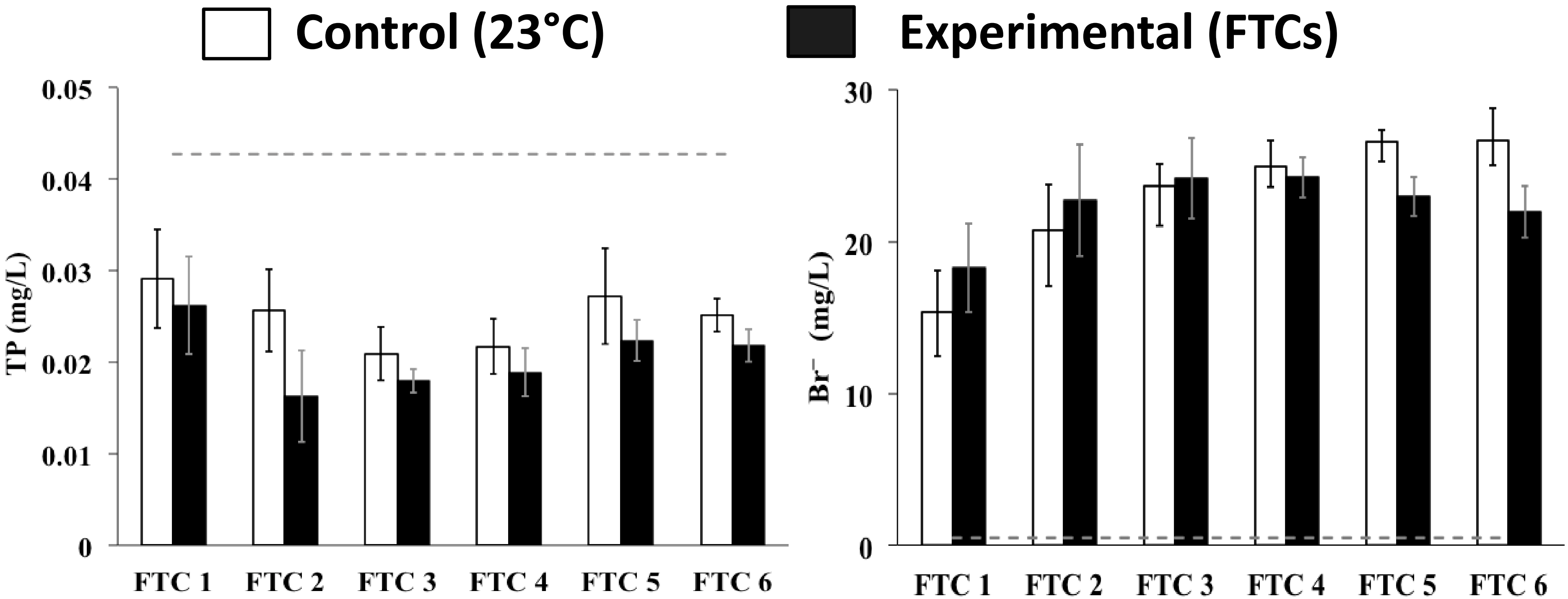




- More TDFe in control column
- Higher reductive dissolution of Fe oxides
- Reductive conditions in both columns

Phosphorus

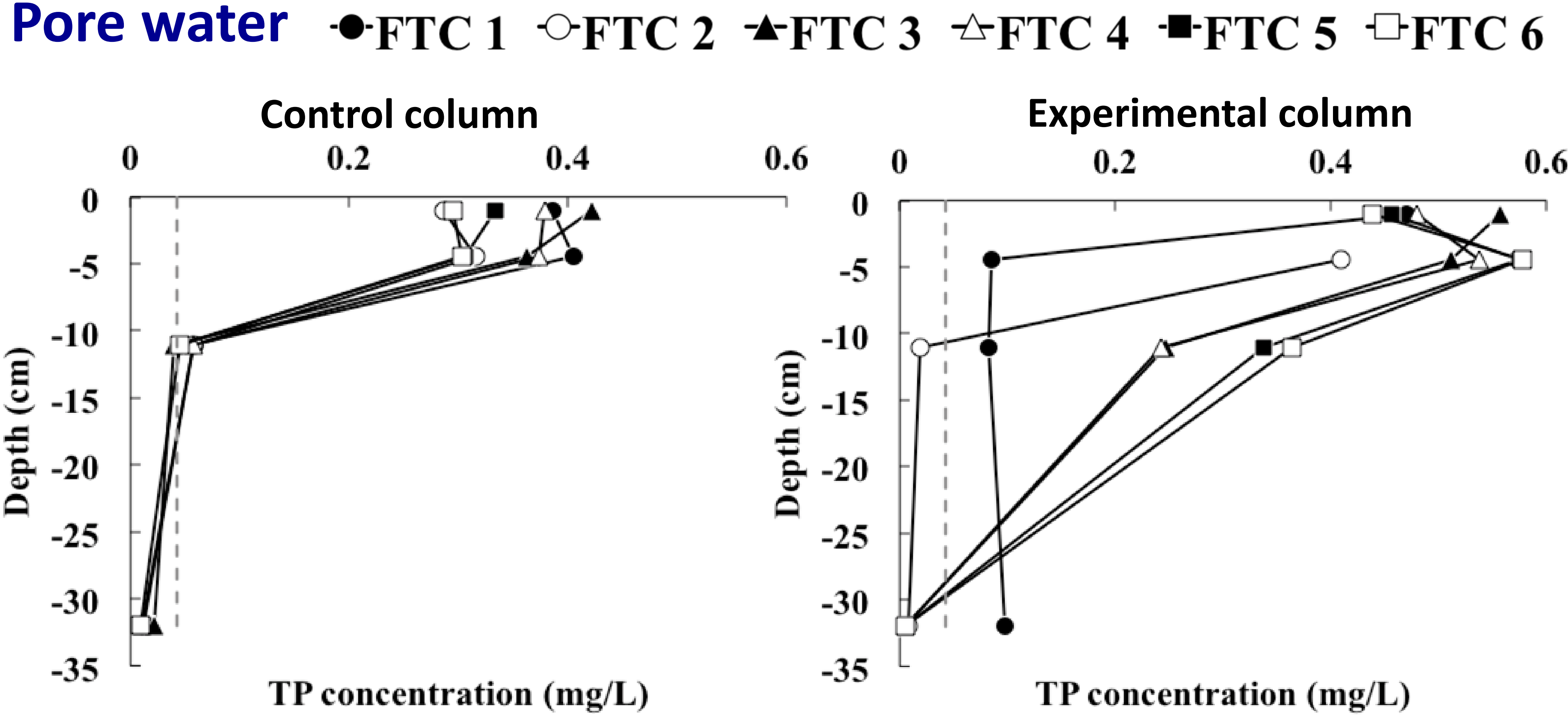
Drainage effluent chemistry



- PO_4^{3-} concentrations below quantification & lower than Br^-'s
- Further elimination processes for PO_4^{3-} compared to Br^-

Phosphorus

Pore water

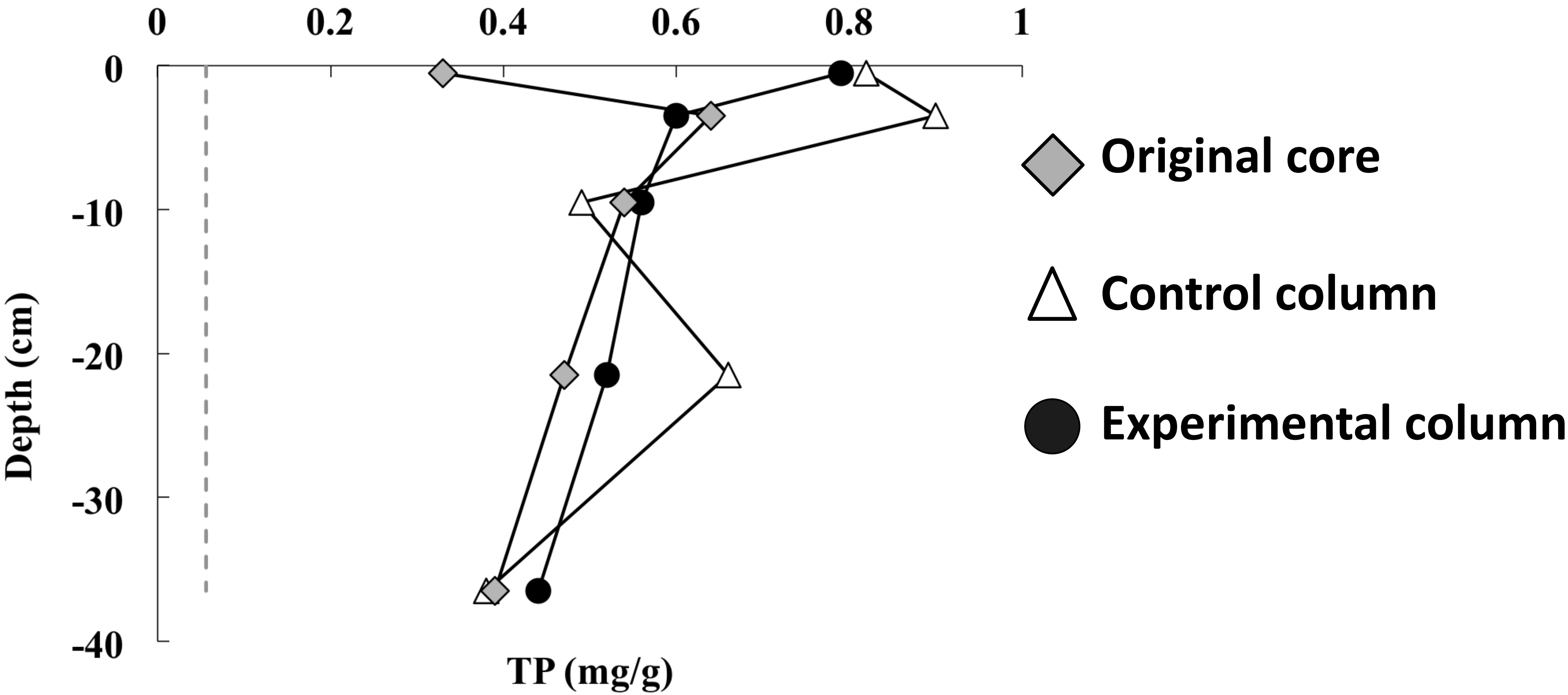


TP concentrations in experimental column:

- were higher than in control
- increased with FTCs

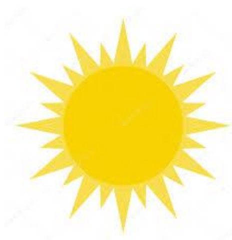
Phosphorus

Soil chemistry



- More TP in control and experimental columns vs. original column
- TP accumulation in top soil
- Less adsorption in the experimental column

Removal Efficiencies



	Control Column	Experimental Column
Nitrate	> 98%	> 96%
Phosphate	> 99%	> 98%

- Very high removal efficiencies for both columns
- Slightly lower for the FTC experimental column

Summary

- FTCs result in increased infiltration rates
- Pores got larger & more connected
- Very high nitrate and phosphorus removal
- Anaerobic microbial nitrate removal
- Phosphorus adsorption in top of columns
- FTCs seemed to reduce P adsorption

Design implications

- To maintain high infiltration
  - FTC no negative effect
- To eliminate NO_3^-
  - Internal water storage zone below freezing zone
  - Maintain high retention time
- To eliminate PO_4^{3-}
  - Use Al oxides-enriched media
  - Deep media below freezing to capture desorbed P

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