Sustainable Technologies
EVALUATION PROGRAM

Equitable Responsibility for Transformational Design:

Optimization of stormwater management within the East Holland River watershed

STEP Webinar

March 4, 2021

Ben Longstaff, LSRCA

Dustin Bambic, Paradigm Environmental

Tracy Patterson, Freeman Associates

Lake Simcoe Region
conservation authority

FREEMAN
Associates

PARADIGM
ENVIRONMENTAL

Problem statement

- Municipal boundary, public land-based stormwater planning & management
- After-the-fact mitigation a significant factor in stormwater planning
- End-of-pipe focus of SWM, with ad hoc approach to LID
- Growing municipal deficit

Lack of integrated, watershed scale, system-level cost-benefit optimization.

Municipal stormwater & wastewater deficit (1996 -2016)
Source FCM

A re-tooling of SWM is needed:

SWM plans that build toward holistic, systemic planning that mimics pre-development, watershed-scale hydrology.

Study principles

1. Using an **optimization methodology** for SWM planning will significantly expand the scope and depth of Stormwater Control Measures (SCMs) evaluation, **providing for more efficient strategies.**
2. Siting SCM on **private & public properties** (vs public properties only) will provide improved performance at **greater cost-efficiency**.
3. Planning and managing stormwater using a **watershed wide framework** will provide improved performance at **greater cost-efficiency** as compared with municipal-scale planning (equitable responsibility)
4. Phosphorus reduction strategies also have **significant co-benefits for peak flow control**
5. **Climate change** and additional urbanization will exacerbate challenges and further support need for systems-based approach

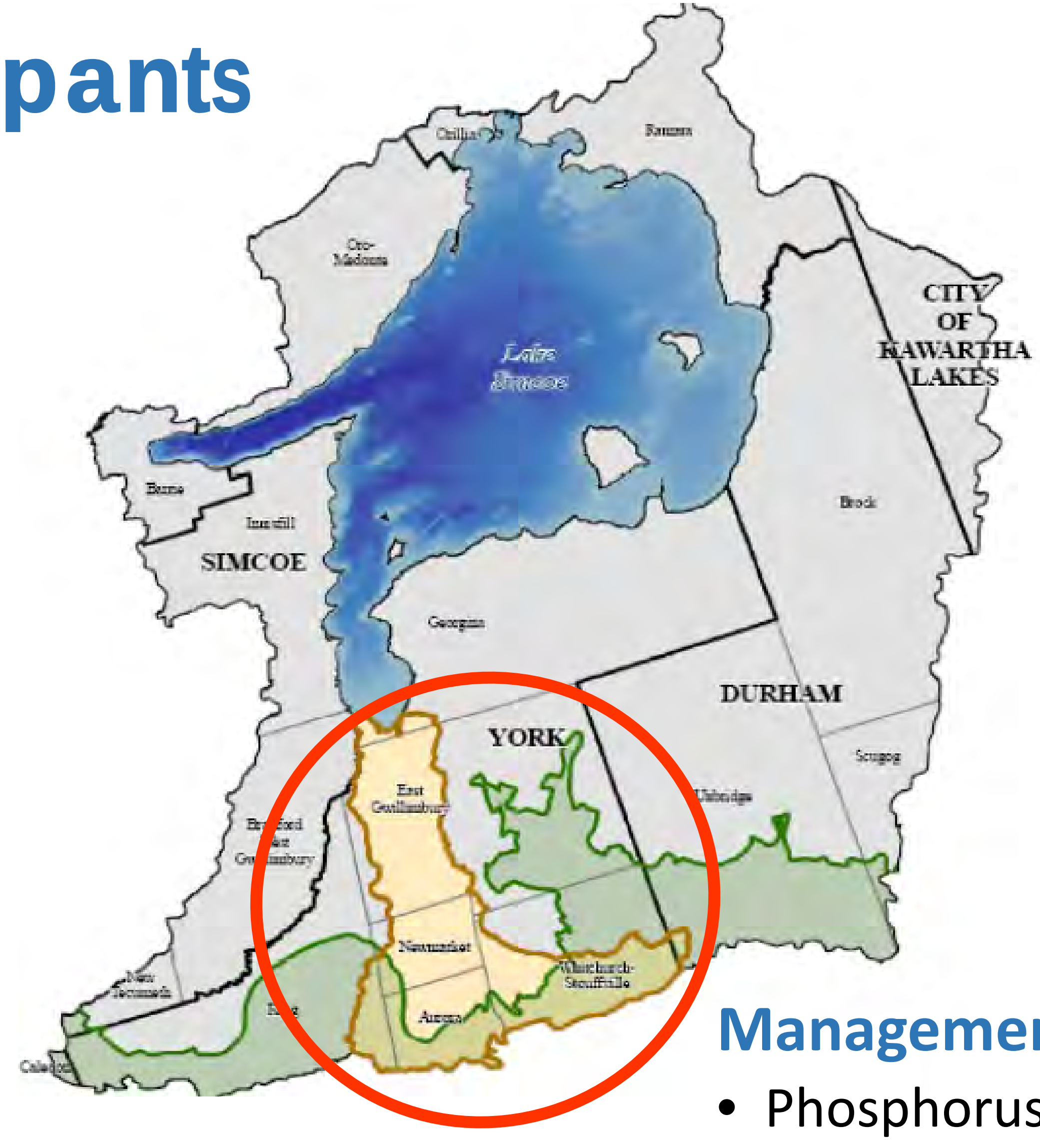
Study area and participants

East Holland River

- Peri-urban
- Growth and intensification
- Municipal Boundary ≠ Watershed Boundary
- Five municipalities

Technical Advisory Committee

- East Holland River municipalities
- MECP
- TRCA and CVC (STEP Partners)
- Project team



Management objectives

- Phosphorus reduction (40%)
- Flood mitigation

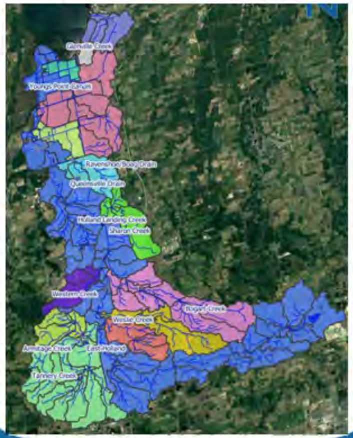
Process-based Optimization Framework

LSPC
Current State Model

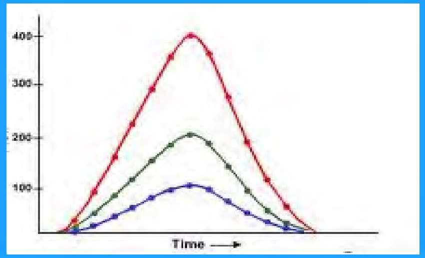
Input
- Climate / Rain / Snow
- Land Use / Soils
- Slope / Imperviousness
- Impoundments
- Point sources /diversions
- And much more

Output
- Continuous simulation time series of flow & contaminants for each subwatershed and reach outlet

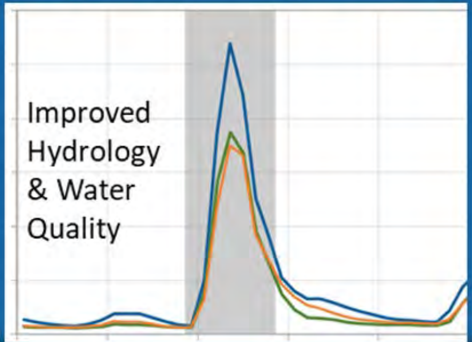
East Holland



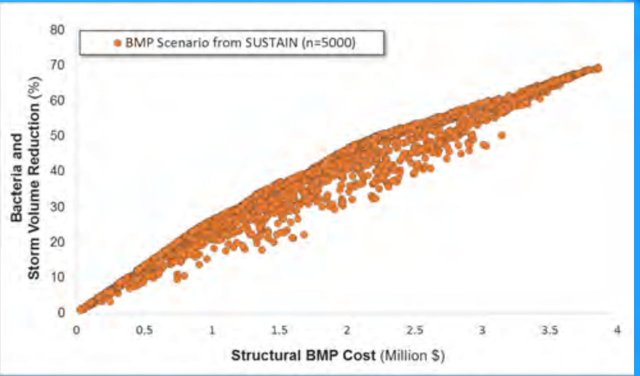
Baseline Conditions
Runoff
Sediment
Phosphorus



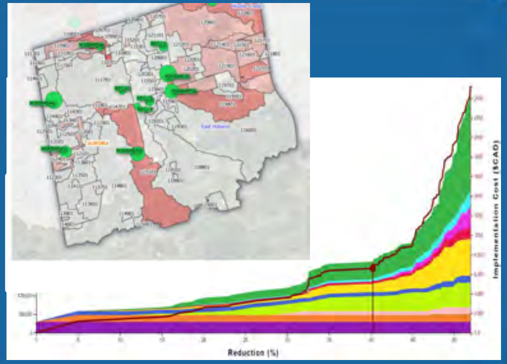
SUSTAIN
Stormwater Management Model
- Time series after implementation of optimized action plan



COST OPTIMIZATION ACROSS MILLIONS OF POTENTIAL STRATEGIES



Outputs to Support Policy Decisions



Study methodology

Simulate current conditions:

- Phosphorus
- Stream flow

Build future state model:

→Select stormwater control measures

- Decentralized (LID) & Centralized (e.g. hybrid ponds)

→ Performance of selected stormwater controls (e.g. P removal)

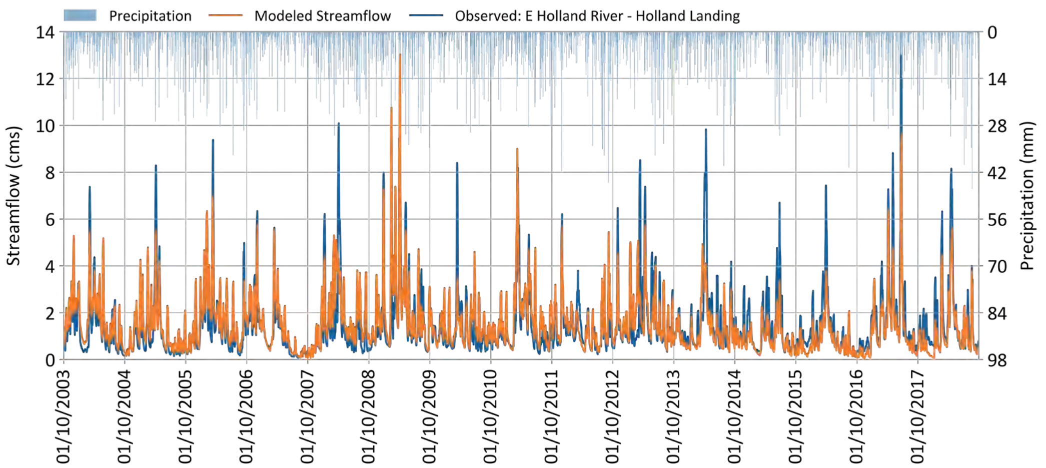
→ Cost of selected Stormwater control (capital, O&M)

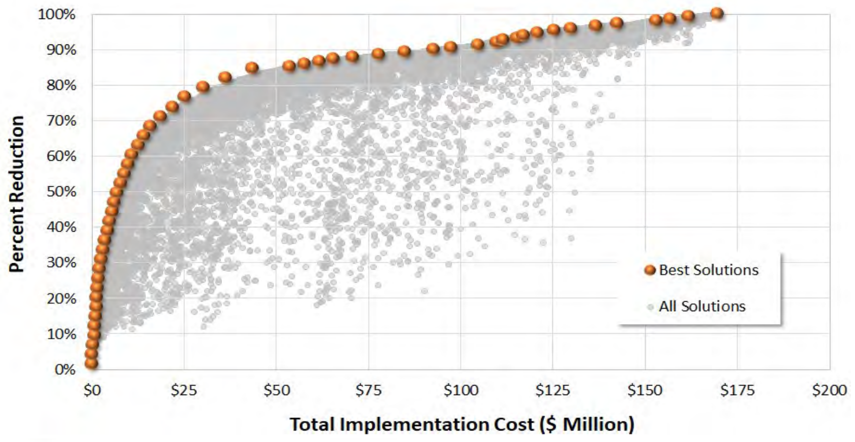
Optimization simulations:

→ Watershed scale

→ Public vs public and private lands

→ Watershed vs Jurisdictional





Study methodology

Simulate current conditions:

- Phosphorus
- Stream flow

Build future state model:

→Select stormwater control measures

- Decentralized (LID) & Centralized (e.g. hybrid

→ Performance of selected stormwater controls (e.g. P removal)

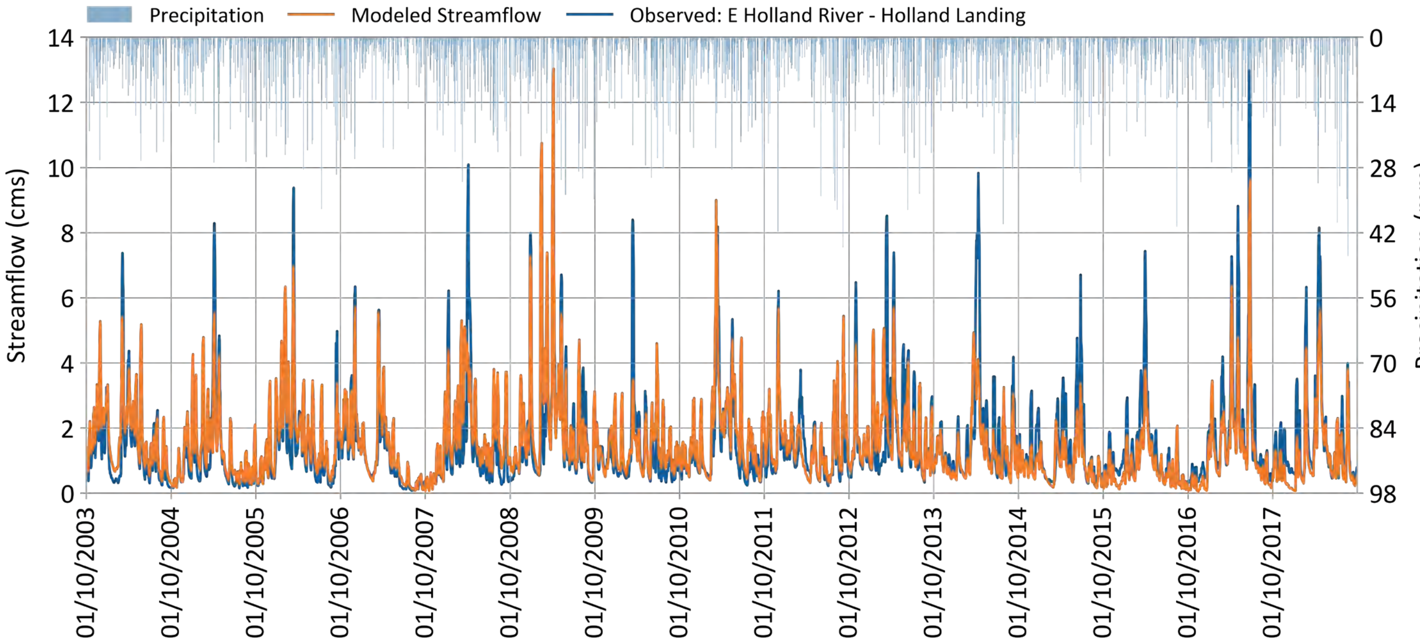
→ Cost of selected Stormwater control (capital, O&M)

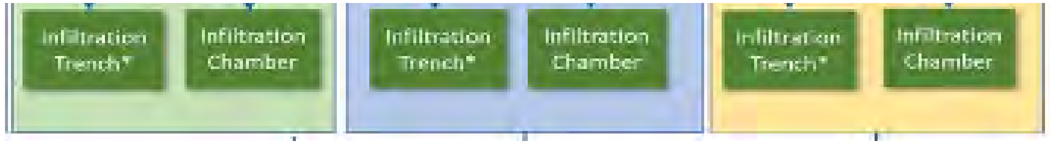
Optimization simulations:

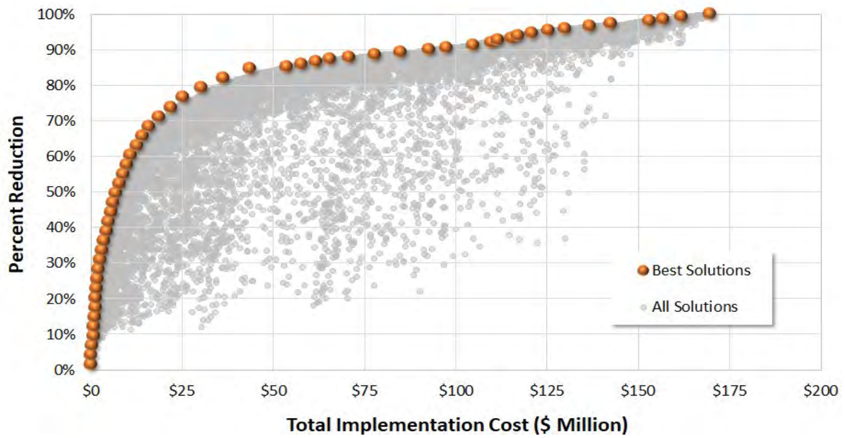
→ Watershed scale

→ Public vs public and private lands

→ Watershed vs Jurisdictional







Study methodology

Simulate current conditions:

- Phosphorus
- Stream flow

Build future state model:

→Select stormwater control measures

- Decentralized (LID) & Centralized (e.g. hybrid ponds)

→ Performance of selected stormwater controls (e.g. P removal)

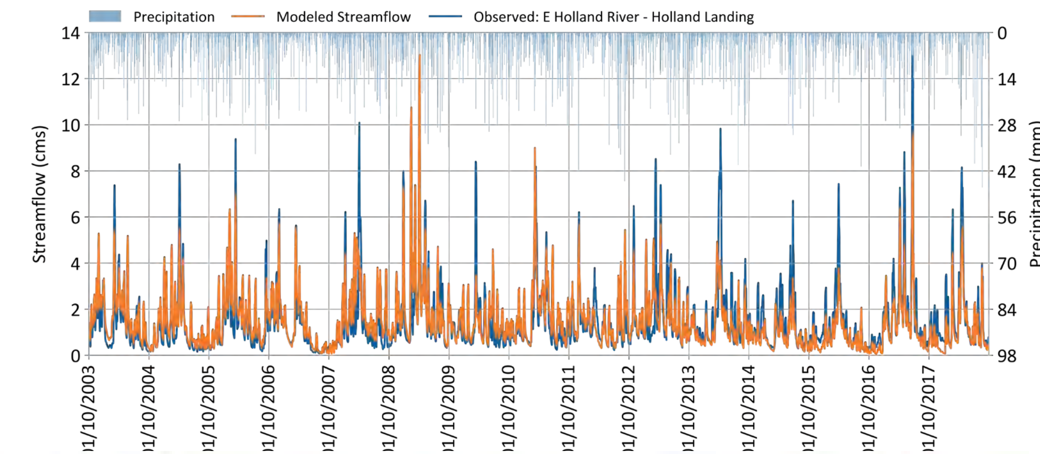
→ Cost of selected Stormwater control (capital, O&M)

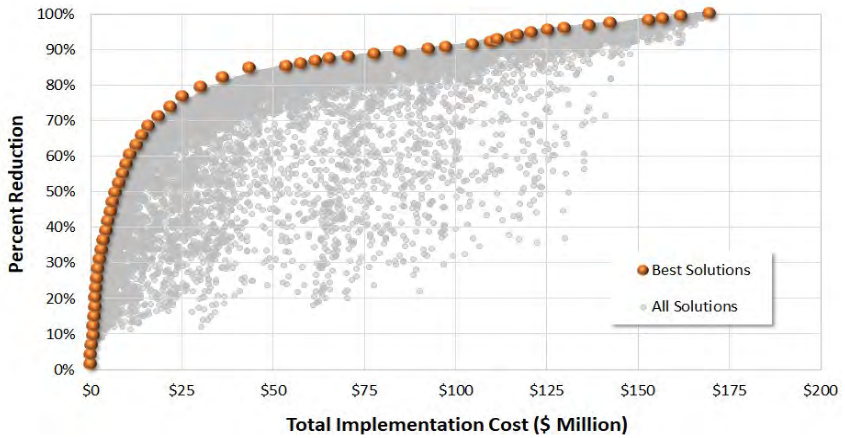
Optimization simulations:

→ Watershed scale

→ Public vs public and private lands

→ Watershed vs Jurisdictional





Study methodology

Simulate current conditions:

→Select stor

- Decen

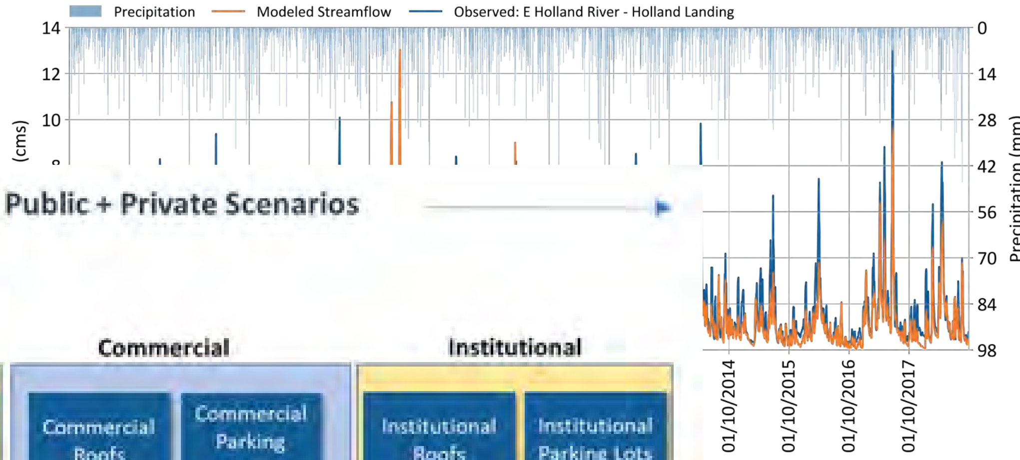
→ Performa

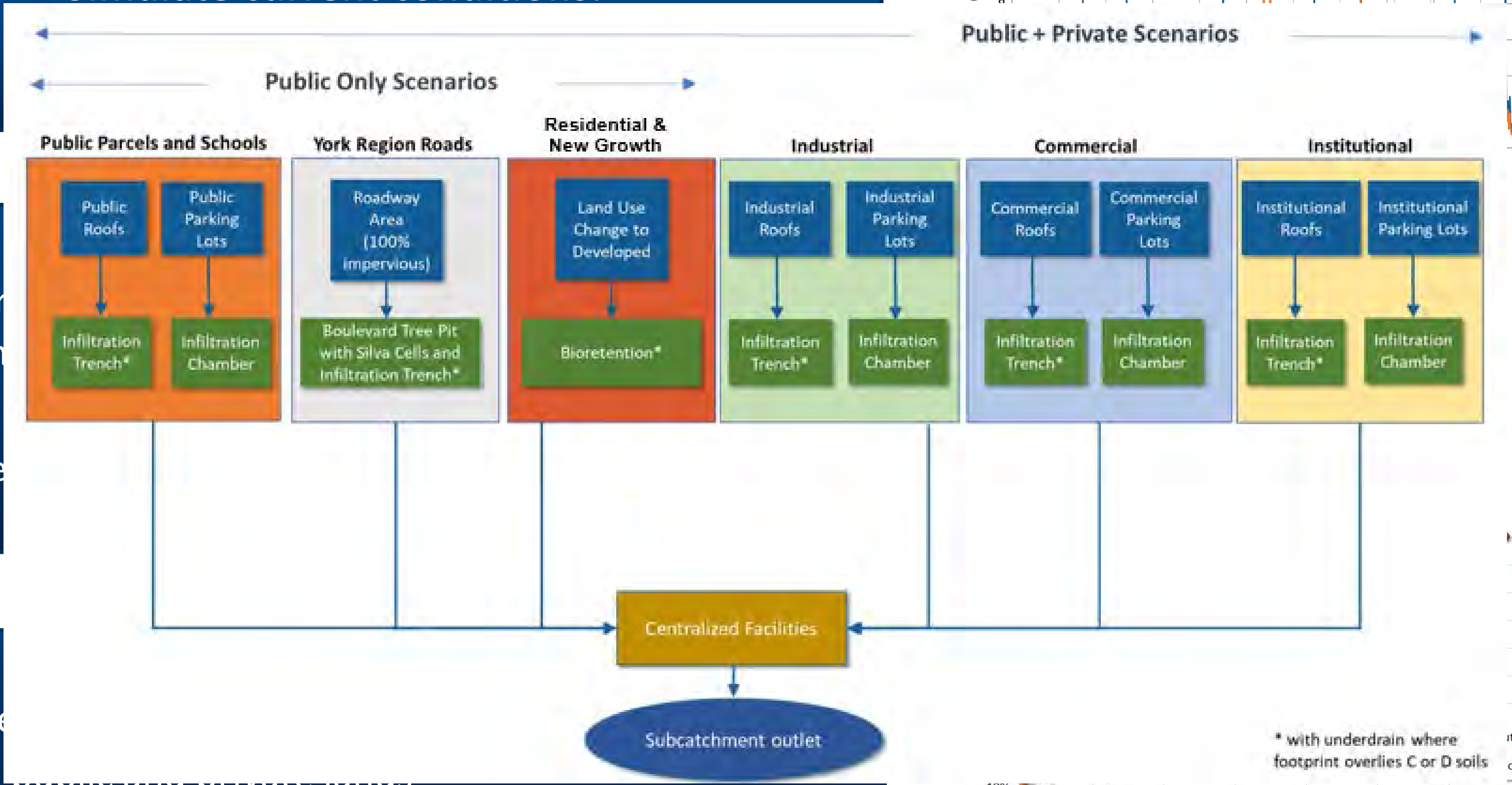
→ Cost of se

→ Watershe

→ Public vs public and private lands

→ Watershed vs Jurisdictional





Study methodology

Simulate current conditions:
- Phosphorus
- Stream flow

Build future state model:

→Select stormwater control measures
- Decentralized (LID) & Centralized (e.g. hybrid ponds)

→ Performance of selected stormwater controls (e.g. P removal)

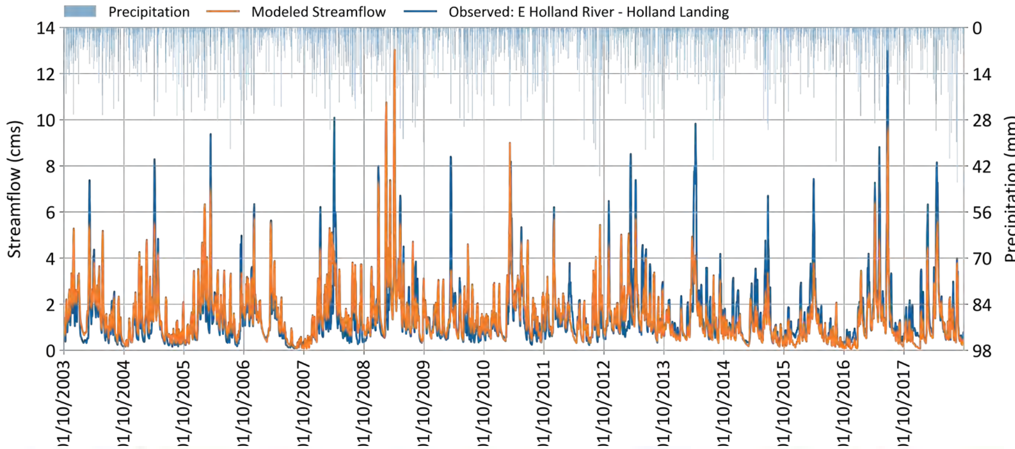
→ Cost of selected Stormwater control (capital, O&M)

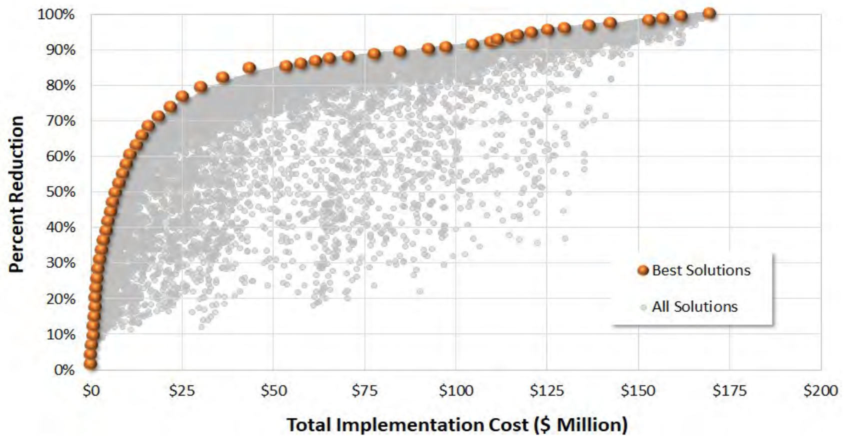
Optimization simulations:

→ Watershed scale

→ Public vs public and private lands

→ Watershed vs Jurisdictional

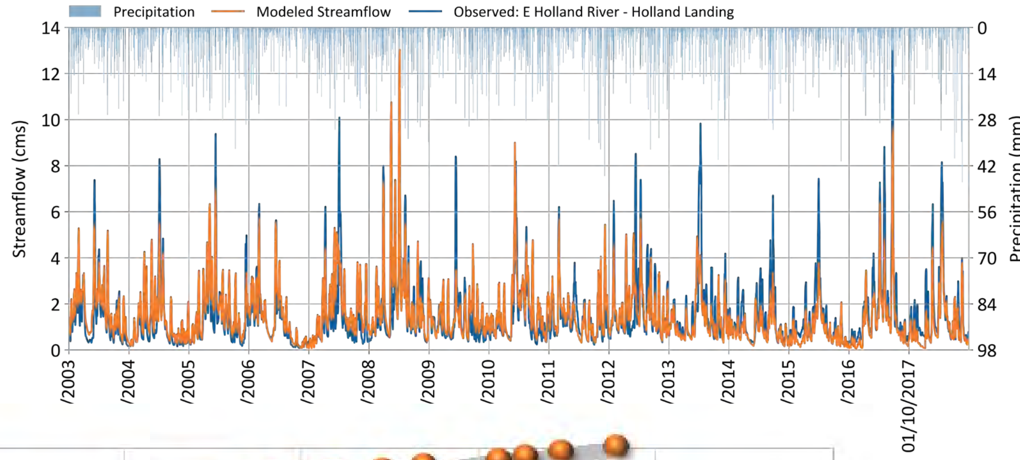




Study methodology

Simulate current conditions:

- Phosphorus
- Stream flow



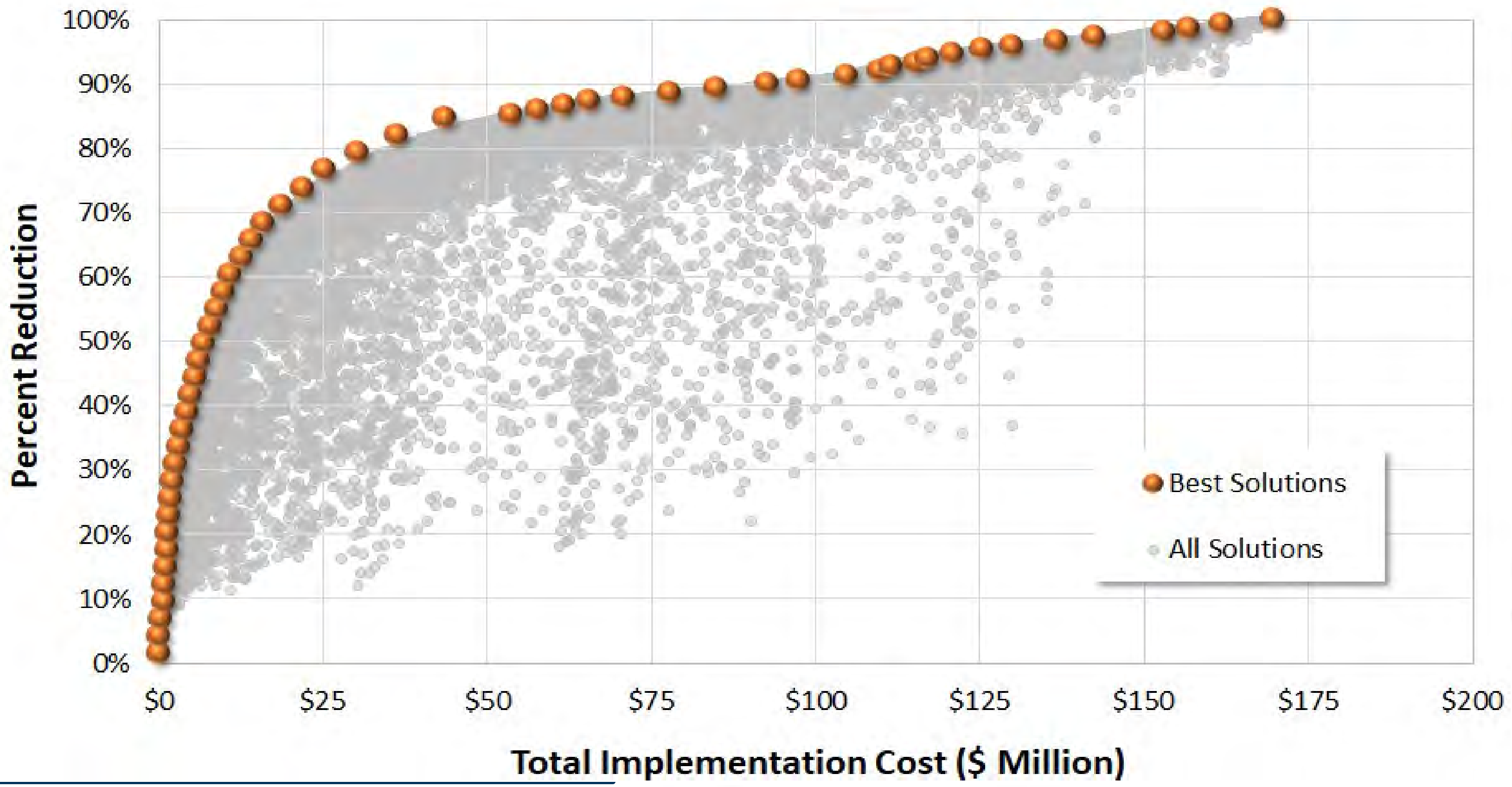
Build future st

→Select stormwater control measu

- Decentralized (LID) & Centra

→ Performance of selected stormw

→ Cost of selected Stormwater cor



Optimization s

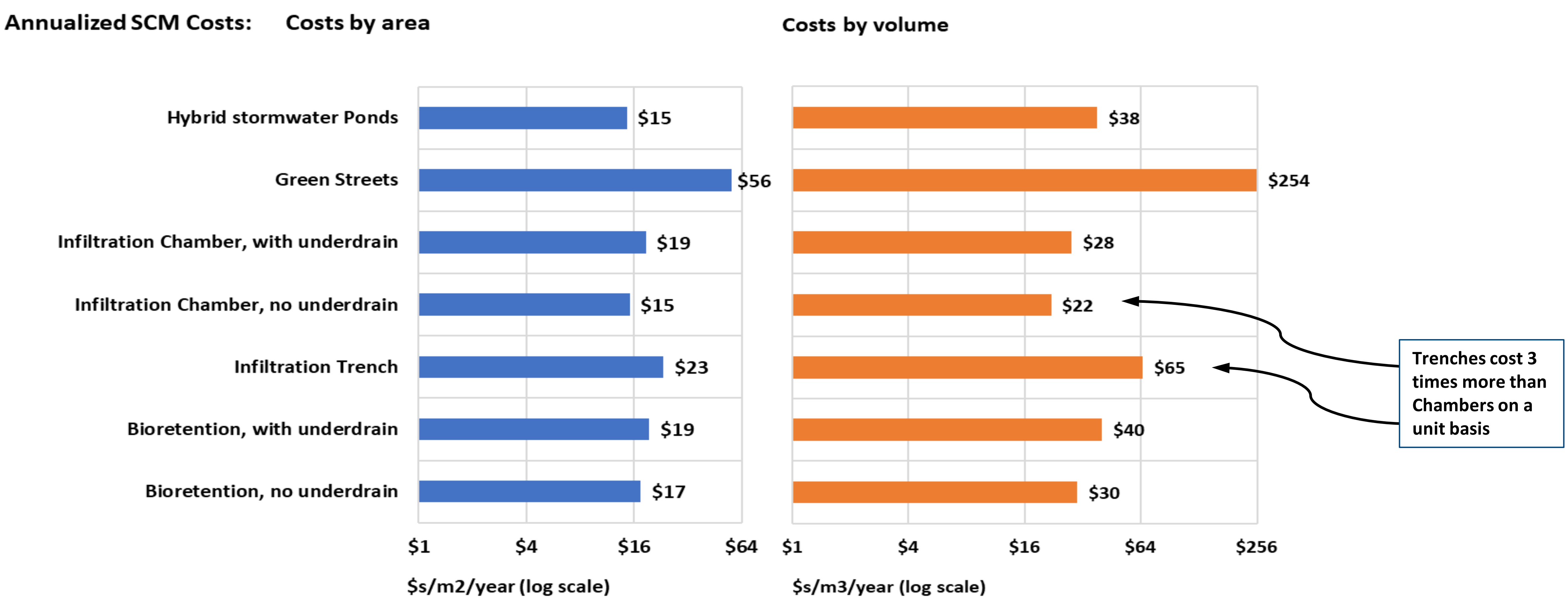
→ Watershed scale

→ Public vs public and private lar

→ Watershed vs Jurisdictional

Typical designs from STEP Life Cycle Costing Tool V2 for most BMPs

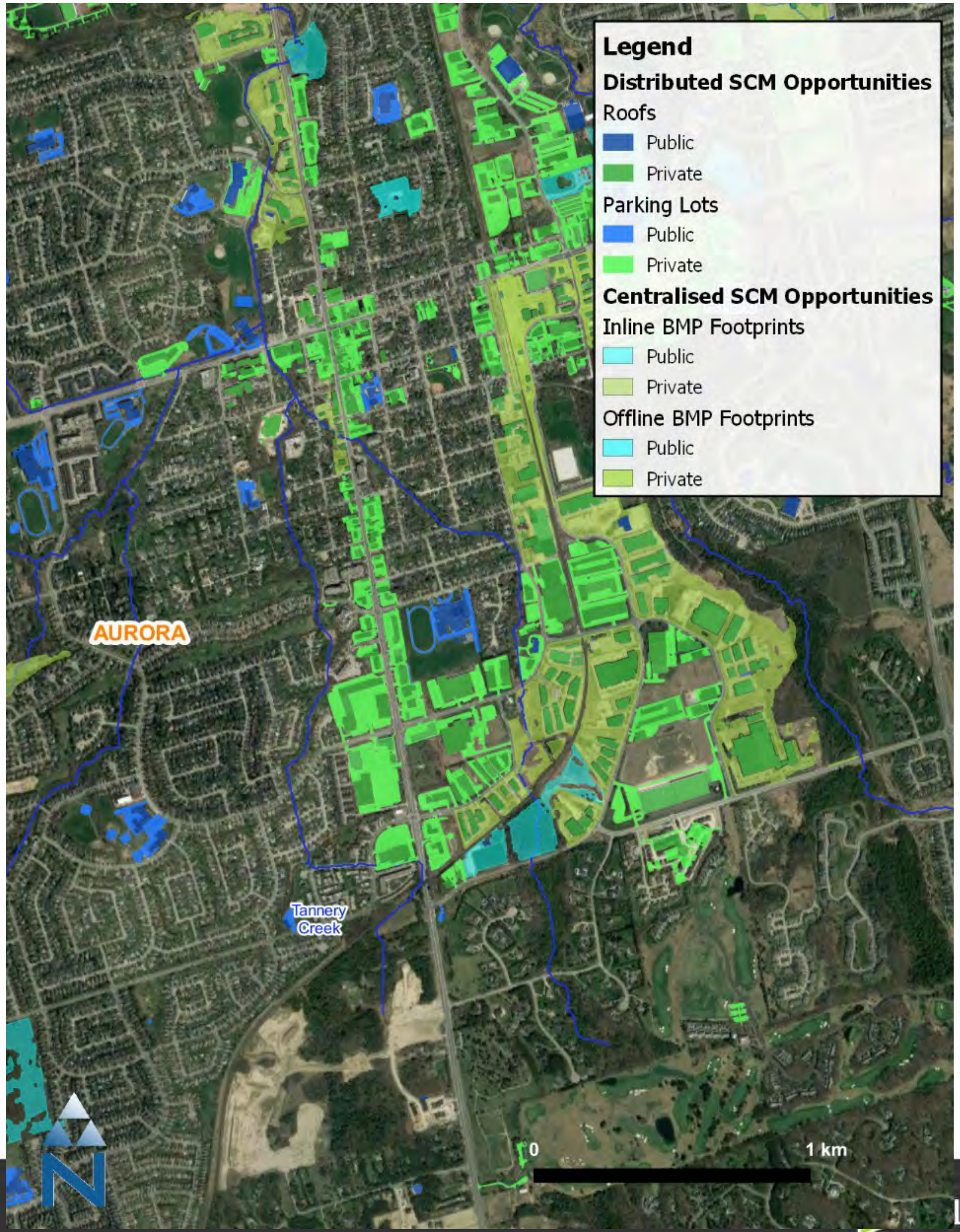
Cost Functions for Representative BMPs

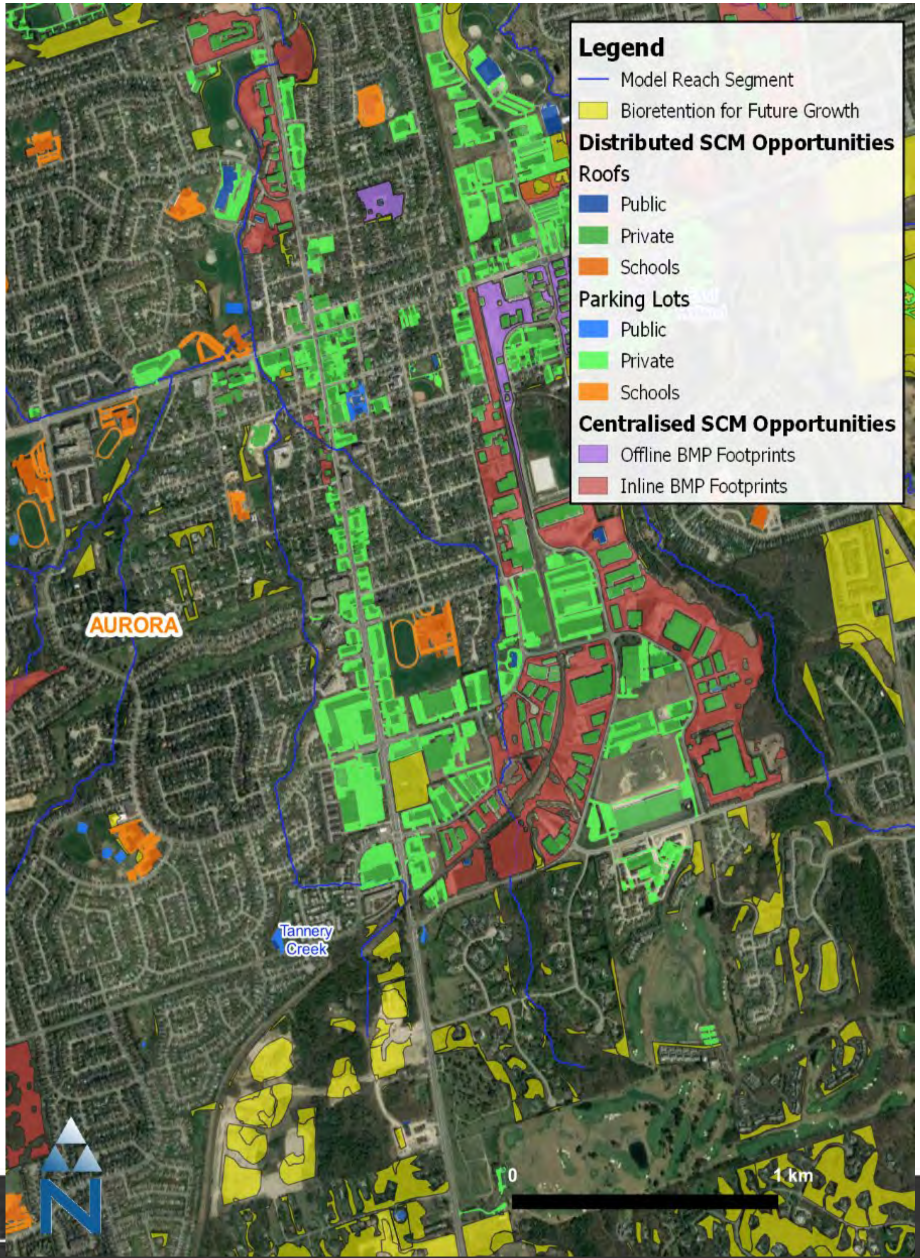


(NOTE: Includes OM costs plus annualized capital costs)

Opportunities for BMP Footprints

- Flagged aggregated parcels where BMPs could be sited
- Based on screening criteria: land use type, available area, distance to stream, depth to groundwater, etc.
- Private and public bins are basis of private vs public scenarios

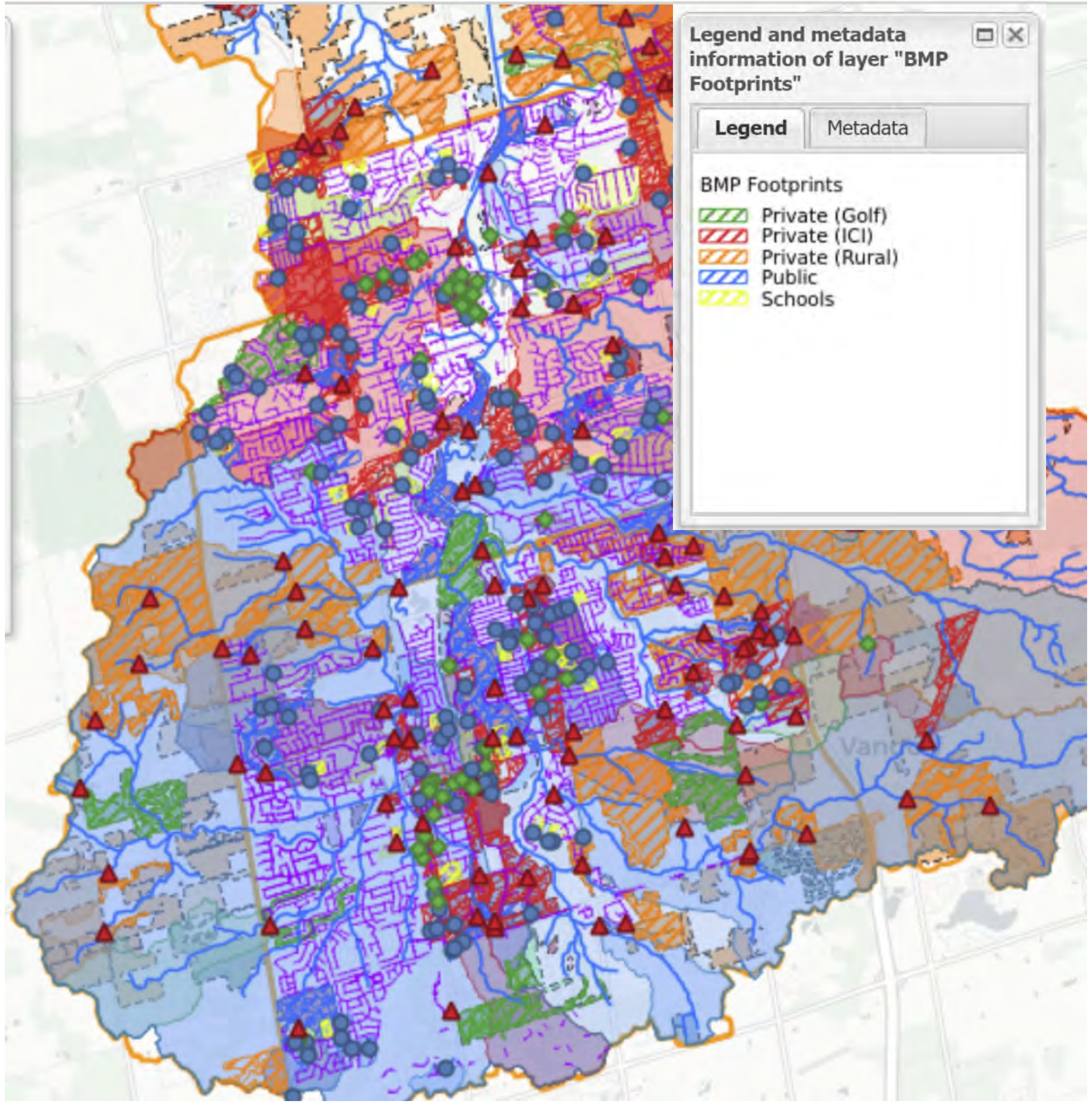




Areas Managed by BMPs

- Distributed BMPs: the drainage areas are rooftops, roads and parking lots (straight-forward)

- Centralized BMPs: larger upstream areas (nested areas that required delineation routines)

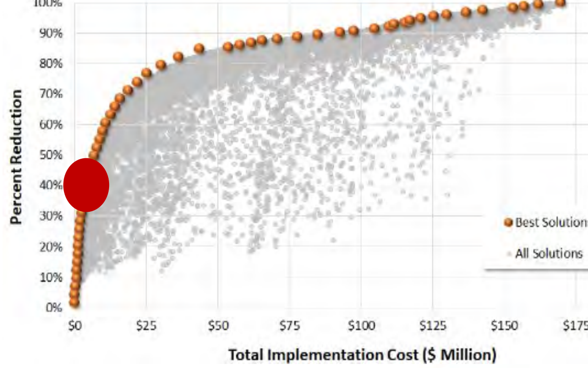


Principle #1

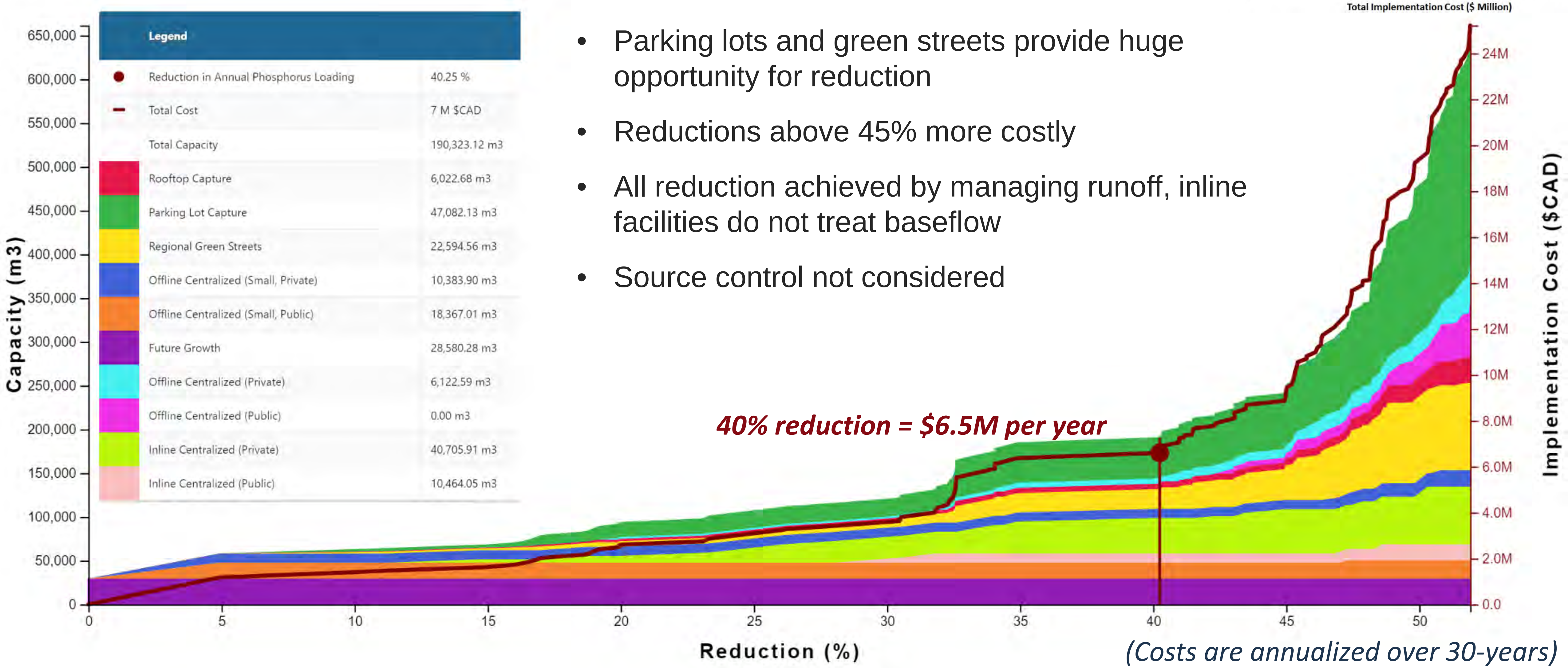
An optimization methodology will result in more efficient stormwater management strategies

Public and Private Opportunities Considered (Costs are annualized over 30-years)

Cost Optimized Implementation Strategy

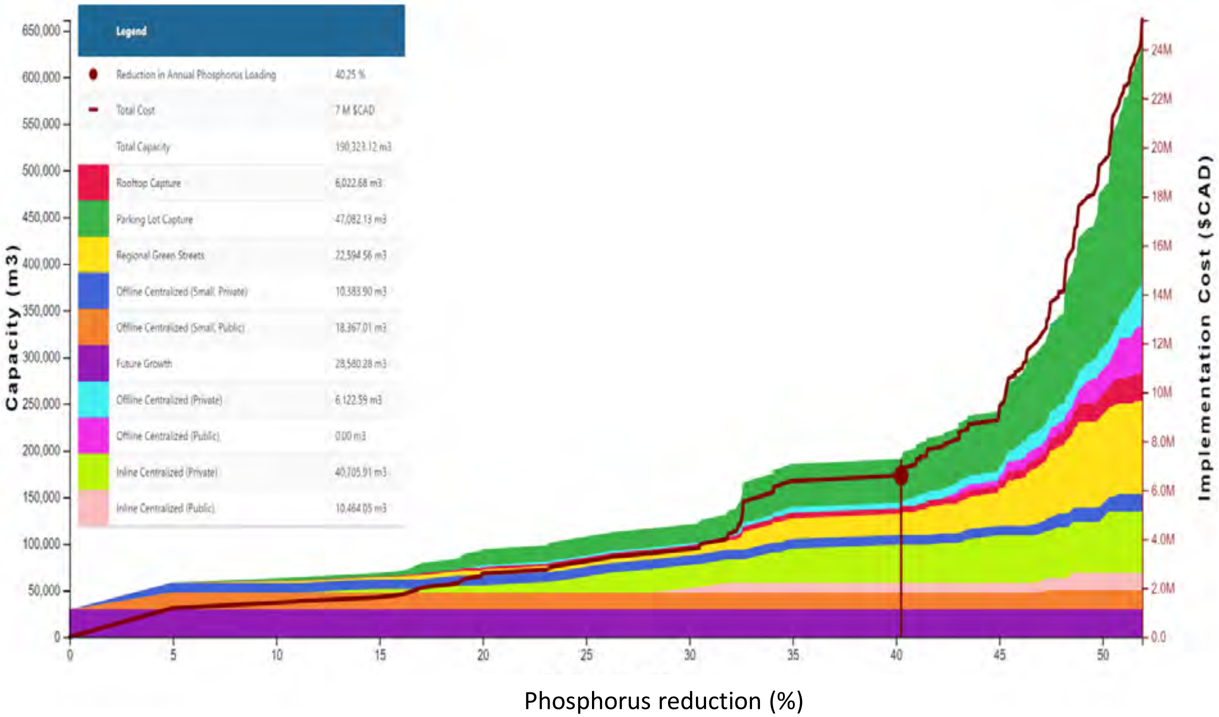


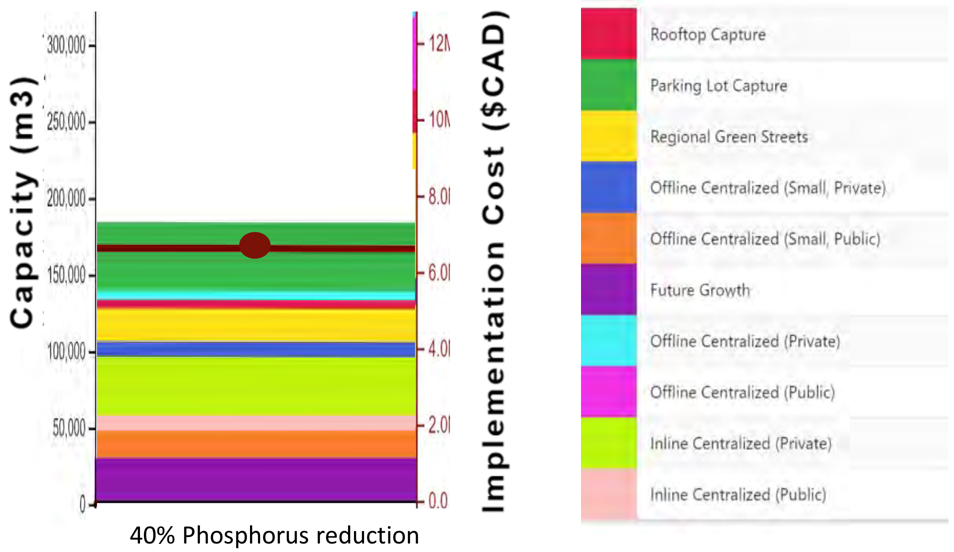
- Inline centralized BMPs most cost effective
- Parking lots and green streets provide huge opportunity for reduction
- Reductions above 45% more costly
- All reduction achieved by managing runoff, inline facilities do not treat baseflow
- Source control not considered



(Costs are annualized over 30-years)

Cost Optimized Implementation Strategy



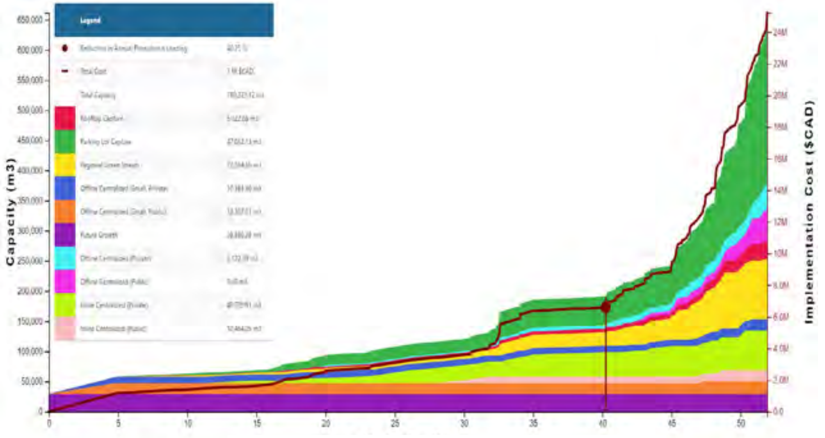


The 40% slice is a basinwide phosphorus reduction strategy to achieve LSPPP targets

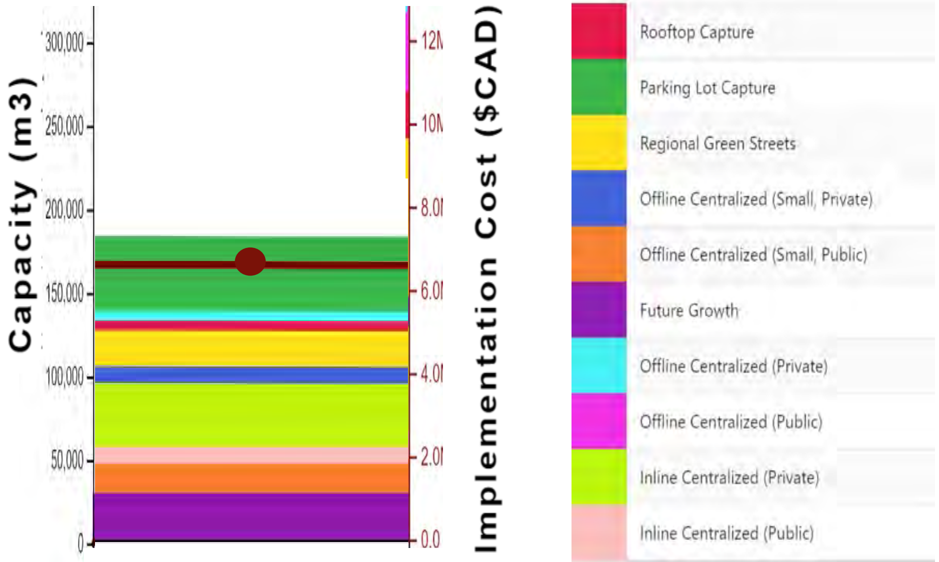
Overall costs to achieve 40% Phosphorus reduction at East Holland Landing Station $6.5 million/yr*

* Includes capital, operational and maintenance expenses annualized over 30 time period

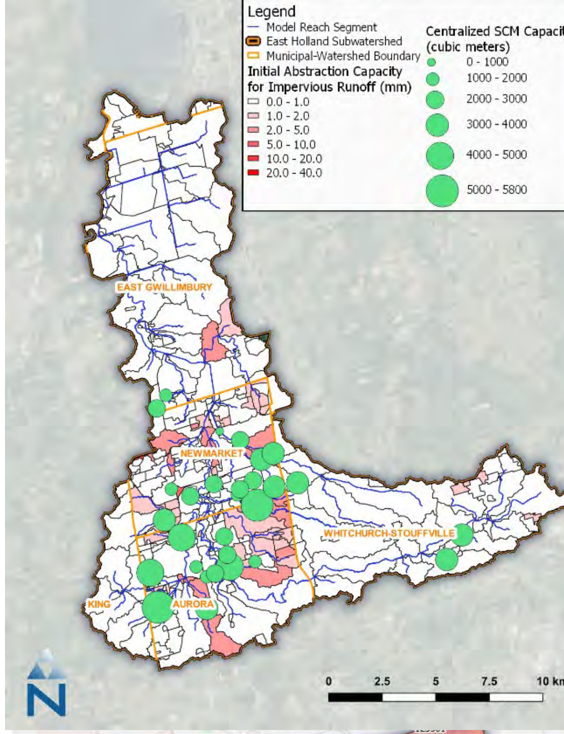
Cost Optimized Implementation Strategy

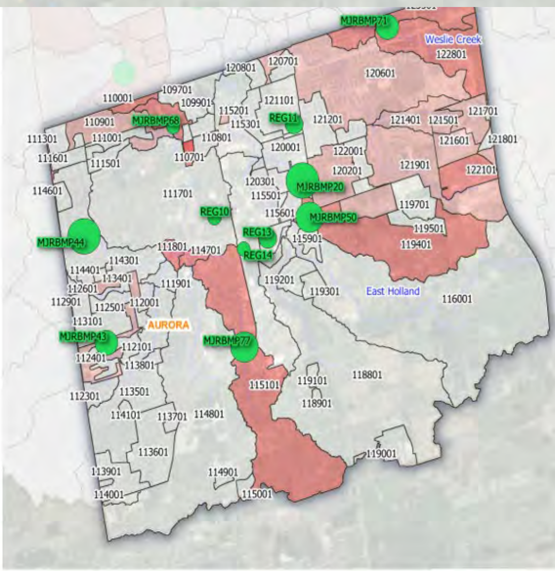


Phosphorus reduction (%)



40% Phosphorus reduction





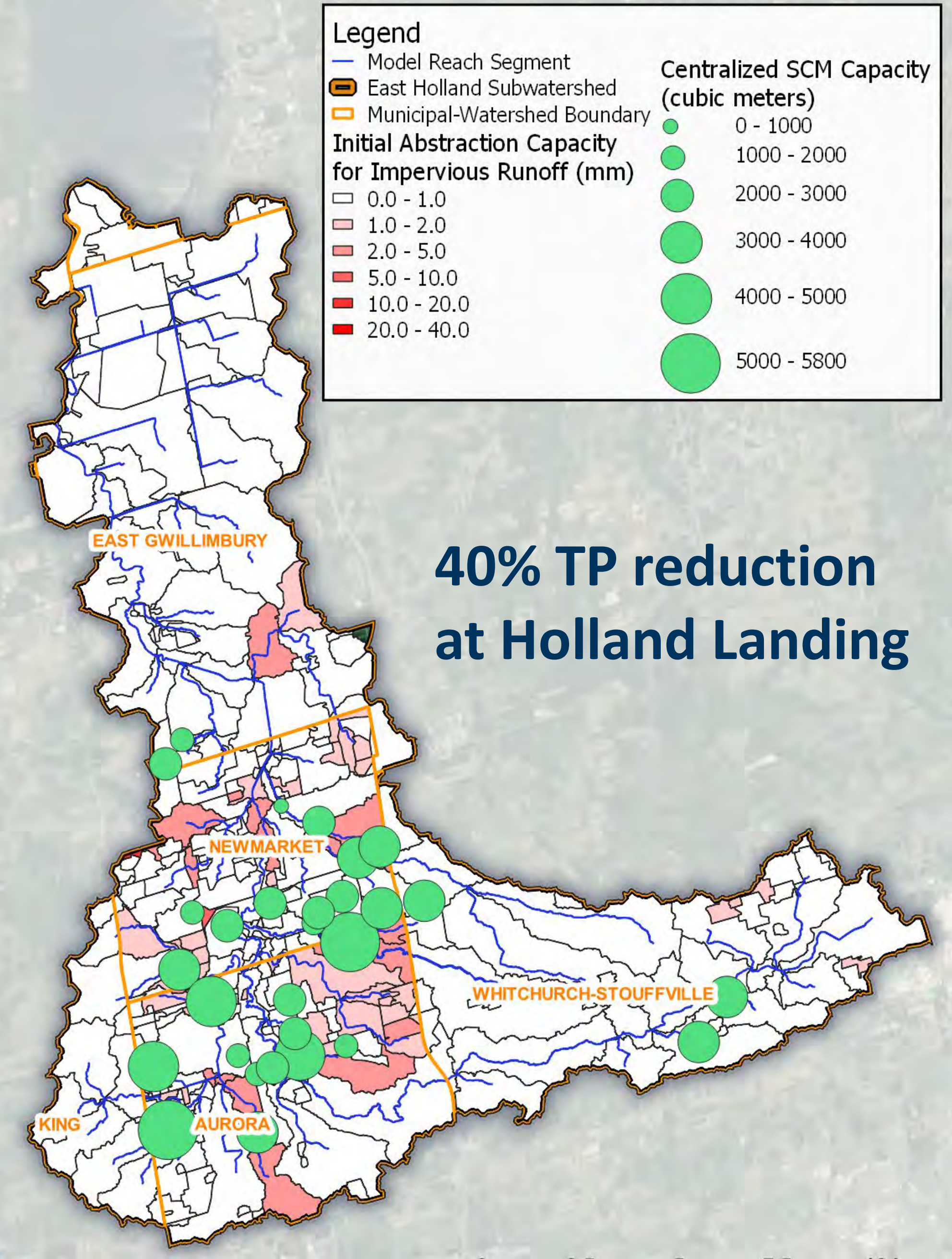
A "strategy" for all phosphorus reduction (%) amounts

Map SWM control measures

Overall costs to achieve 40% Phosphorus reduction at East Holland Landing Station $6.5 million/yr*

* Includes capital, operational and maintenance expenses annualized over 30 time period

Cost Optimized Implementation Strategy



40% TP reduction at Holland Landing

GIS VIEWER

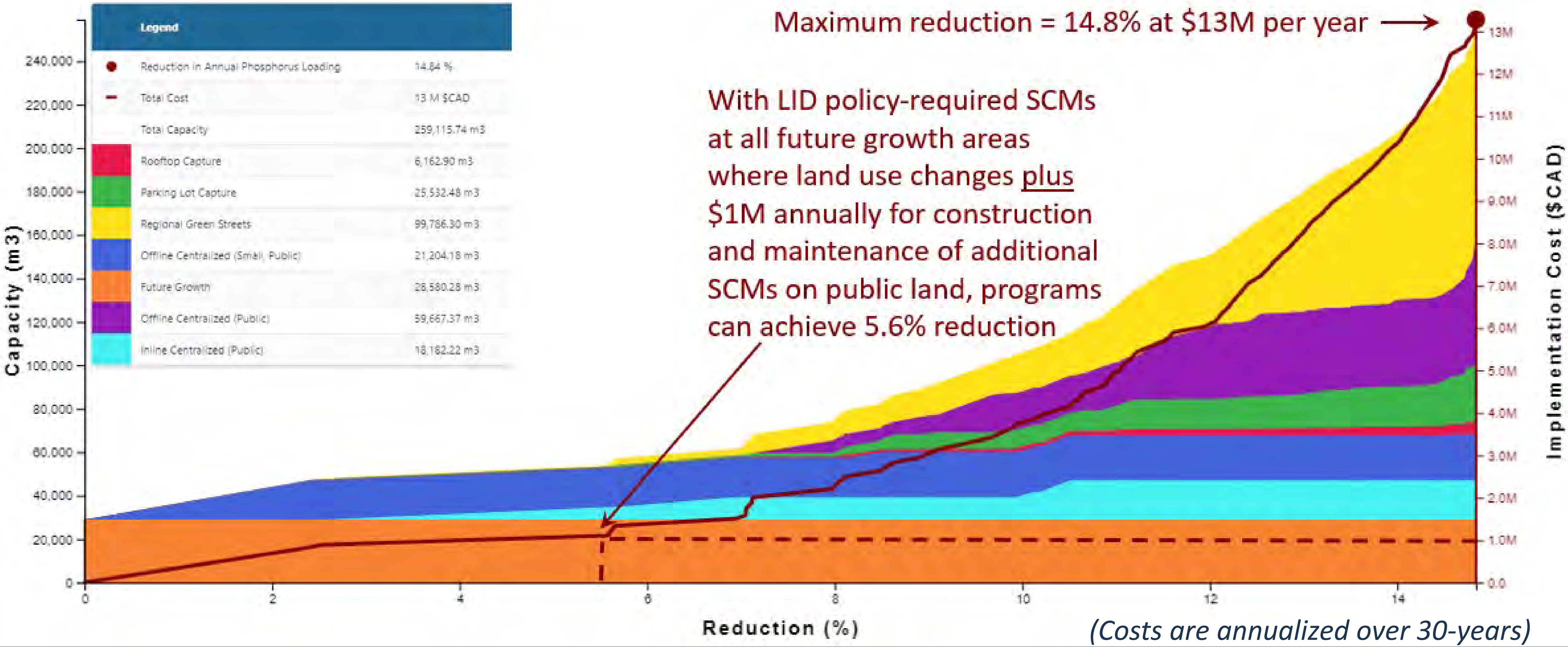
BREAK FOR QUESTIONS

Principle #2

Siting stormwater control measures on private & public properties (vs public properties only) will provide improved performance at greater cost-efficiency.

Public Land Only: Optimized Implementation Strategy

- Available opportunity insufficient to achieve 40% reduction
- Same 14.8% reduction costs only $2M per year when private opps are available.



(Costs are annualized over 30-years)

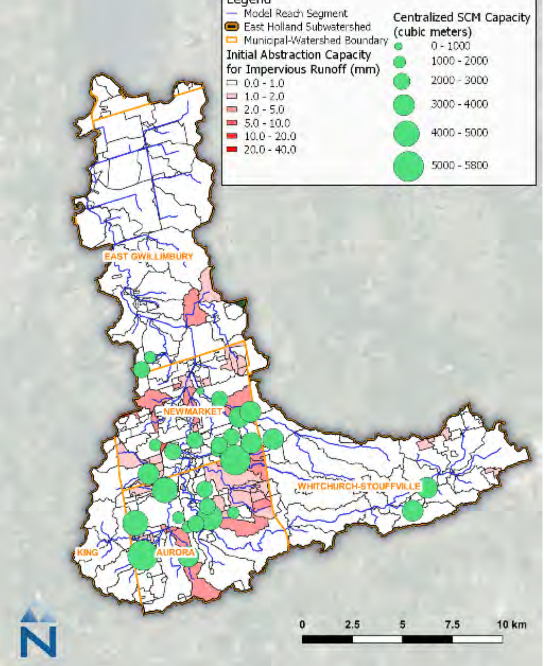
Public vs public & private lands

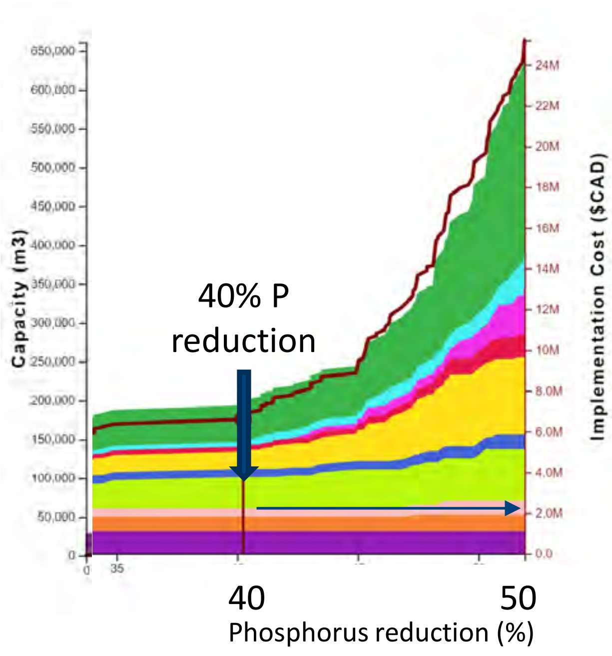
Private & Public land:

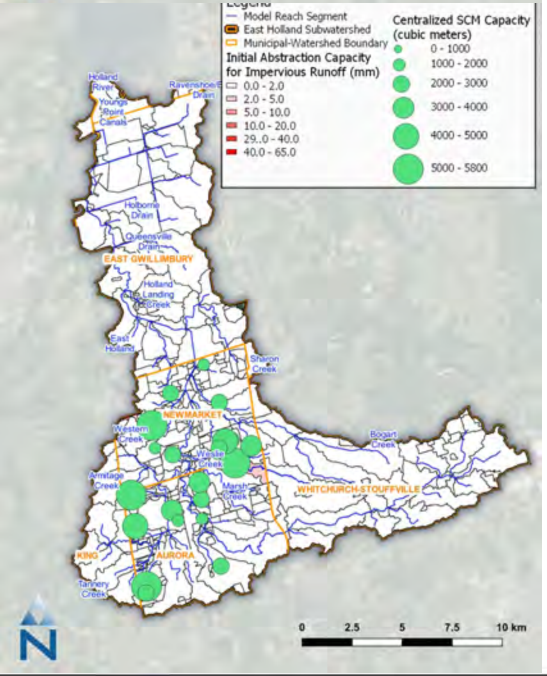
- 40% phosphorus reduction achieved at $6.5 million/year

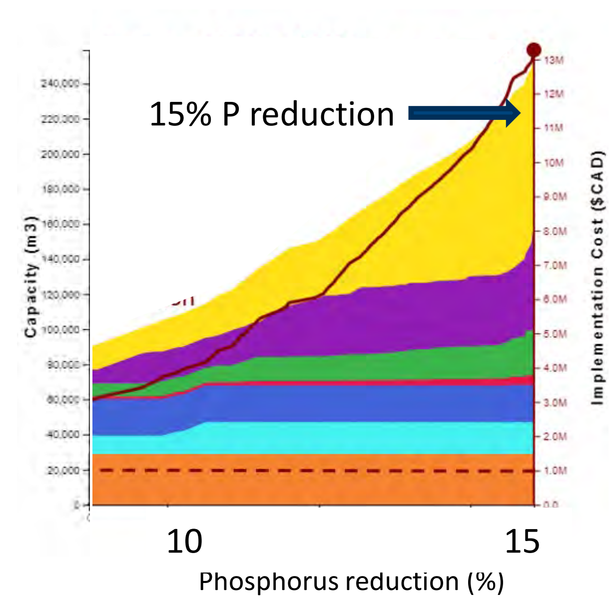
Public lands only

- 15% maximum phosphorus reduction at $13 million/year







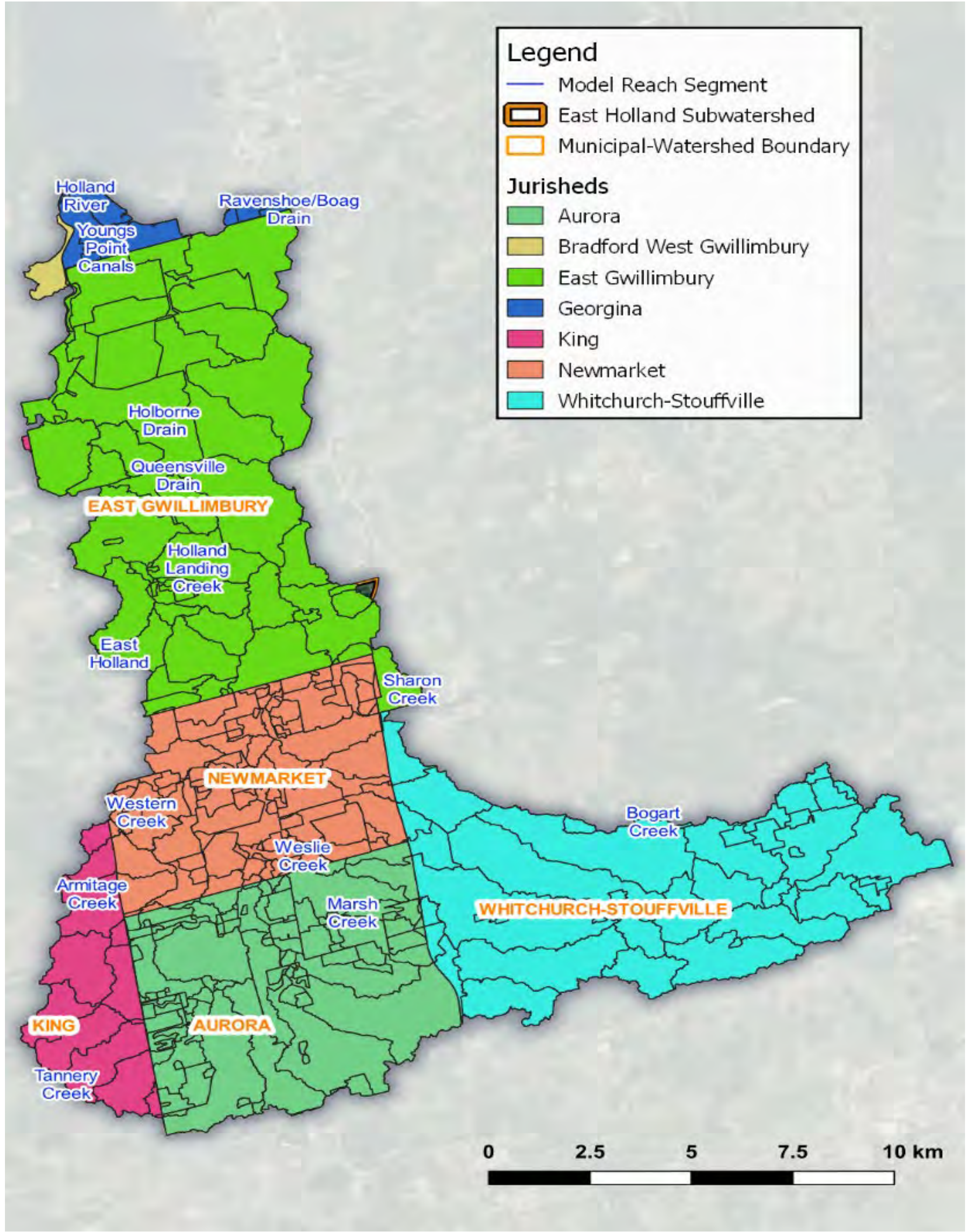


Public – Private Partnership examples:

- Wetland projects on private farmland, (Norfolk County, Alus, AgCan, OMAFRA, Weston Corp)
- District energy partnership (City of Markham, Mattamy Homes Canada and Enwave Energy)

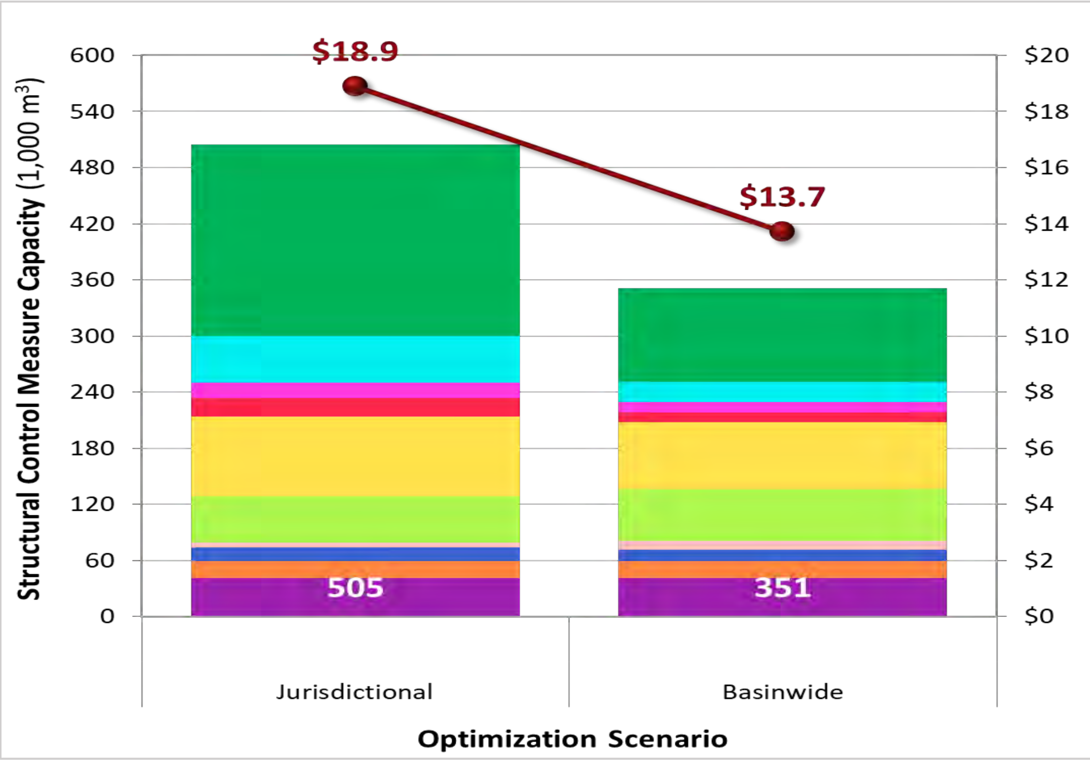
Principle #3

Planning and managing stormwater using a basinwide framework will provide improved performance at greater cost-efficiency as compared with municipal-scale planning.



Jurisdiction vs Basinwide Results

- Watershed-wide collaboration leads to a 28% cost savings and 30% reduction in SCM capacity.
- Intermunicipal collaboration provides for more efficient distributed SCM (e.g. parking lots), economies of scale and increased capacity (e.g. centralized hybrid ponds).



Intermunicipal collaboration examples:

- Central York Fire Services (Aurora and Newmarket).
- Animal Services (Aurora, Georgina and Newmarket).
- Holland Marsh Drainage System Joint municipal Services Board
- York Purchasing Cooperative (all municipalities in Region).

BREAK FOR QUESTIONS

Principle #3

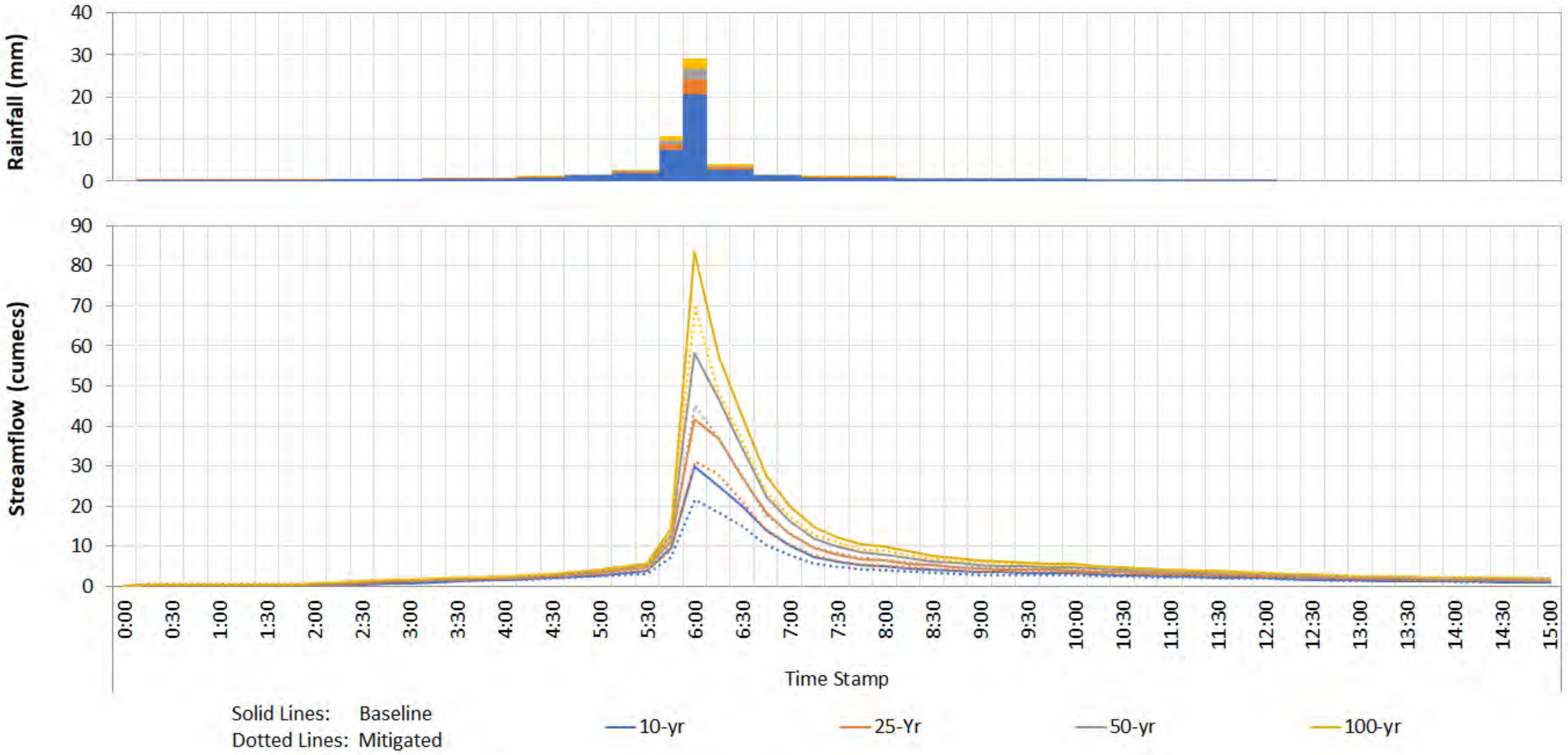
Phosphorus reduction strategies also have significant co-benefits for peak flow control

Principle #4

Climate change and additional urbanization will exacerbate challenges and further support need for systems-based approach

Flood Mitigation Analysis

- Simulated design storms for 5, 10, 25, 50 and 100 year storms
- HEC-RAS used to simulate water levels with each peak flow
- Optimization curves generated for each site to establish the maximum potential *peak flow* and *water level* mitigation from BMPs



Optimization and design storm curves were used to estimate the flooding mitigation that would be achieved by 'phosphorus' BMPs and under climate change weather conditions

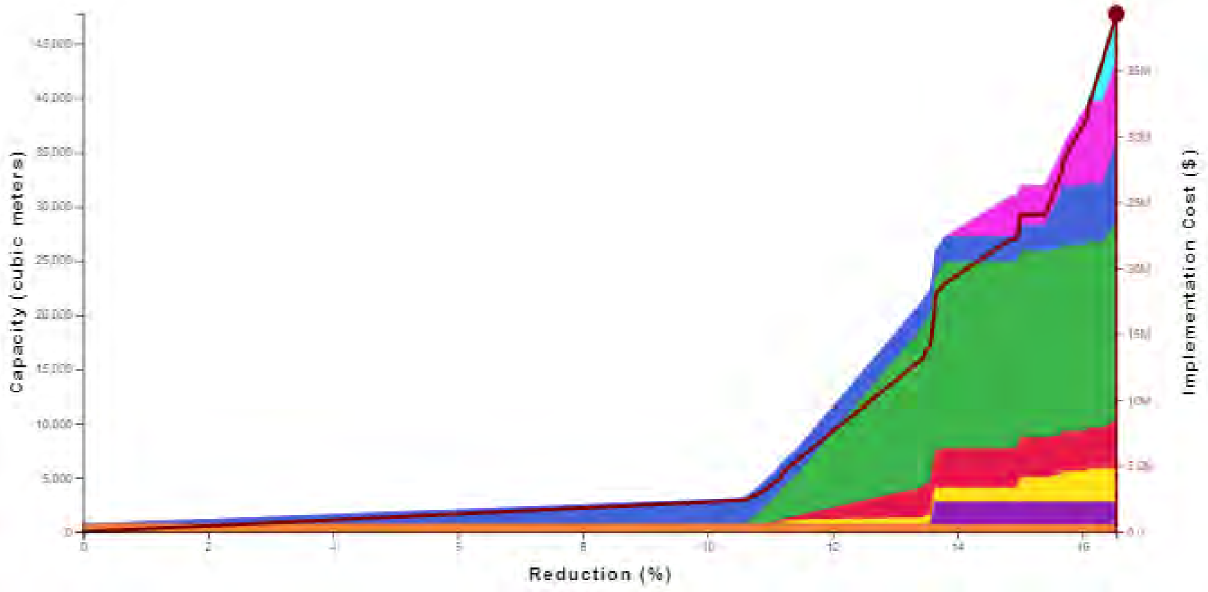
Potential Flood Reduction Benefits by Phosphorus SCMs

- 'Water quality' SCM can substantially reduce peak *flow rates*
- However, peak *water levels*, according to HEC-RAS, are not always sensitive to peak flow reductions.

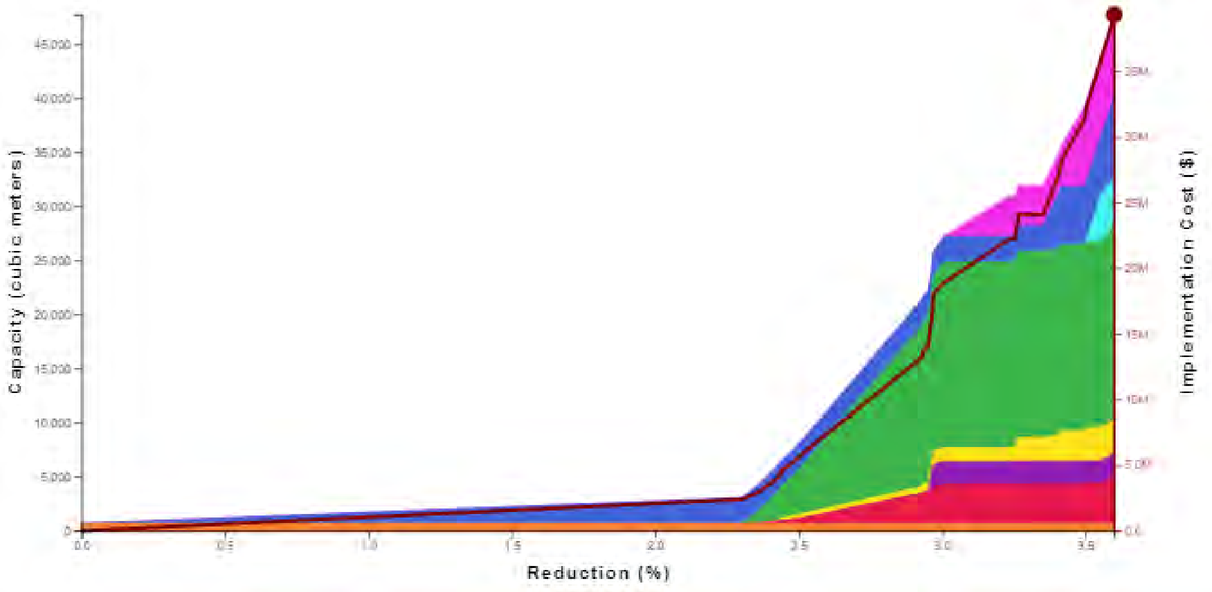
Waterbody	Flood-prone Area ID	Description	Peak Flow				Elevation			
			10 yr	25 yr	50 yr	100 yr	10 yr	25 yr	50 yr	100 yr
Tannery Creek	Area 2	South of Tyler Street at Temperance St	17.21%	16.55%	14.65%	10.12%	7.83%	4.23%	3.14%	0.54%
Tannery Creek	Area 5	Aurora Heights Dr/Machell Park	20.06%	19.04%	16.62%	11.45%	1.93%	2.67%	7.79%	2.72%
Bogart Creek	Area 8	Gorham St to Srigley St	26.12%	24.44%	21.59%	15.68%	2.35%	2.99%	3.51%	3.41%
Western Creek	Area 10	Ontario St, East of Lorne Ave	16.74%	13.95%	13.85%	11.49%	6.84%	2.71%	1.50%	2.50%
Tannery Creek	Area 13	Harriman Driveways	23.79%	21.43%	18.41%	12.56%	8.46%	5.92%	3.73%	3.34%
Tannery Creek	Area 14	Kennedy St West Culert	17.78%	17.62%	15.78%	10.99%	10.65%	9.70%	10.43%	14.46%

Water level reductions much less than peak flow reductions due to constrictions in network.

Example Flood Optimization: 100–year storm at Area 8 (Gorham St to Srigley St, Bogart Creek)

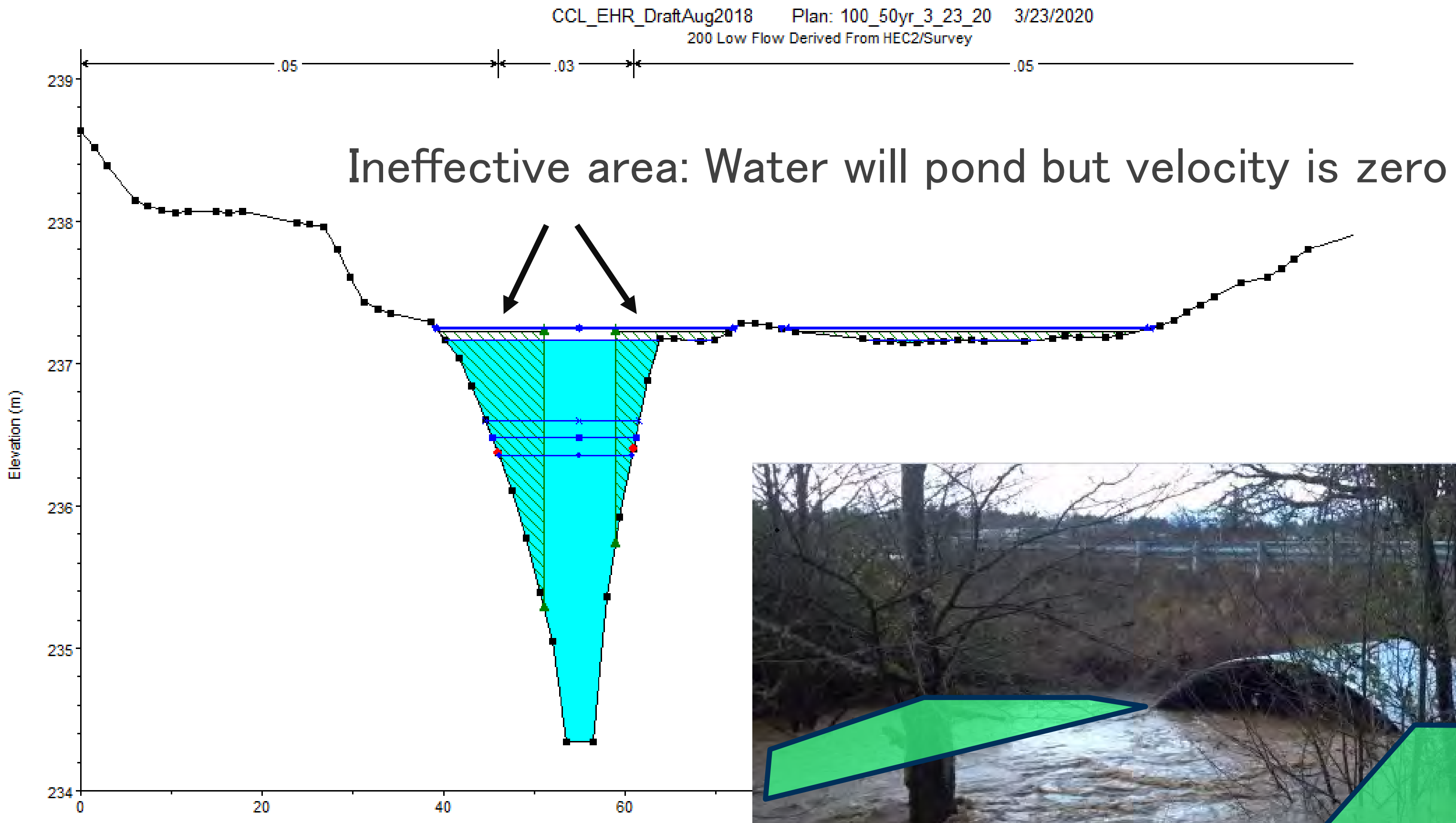


Peak flow: -16.54%

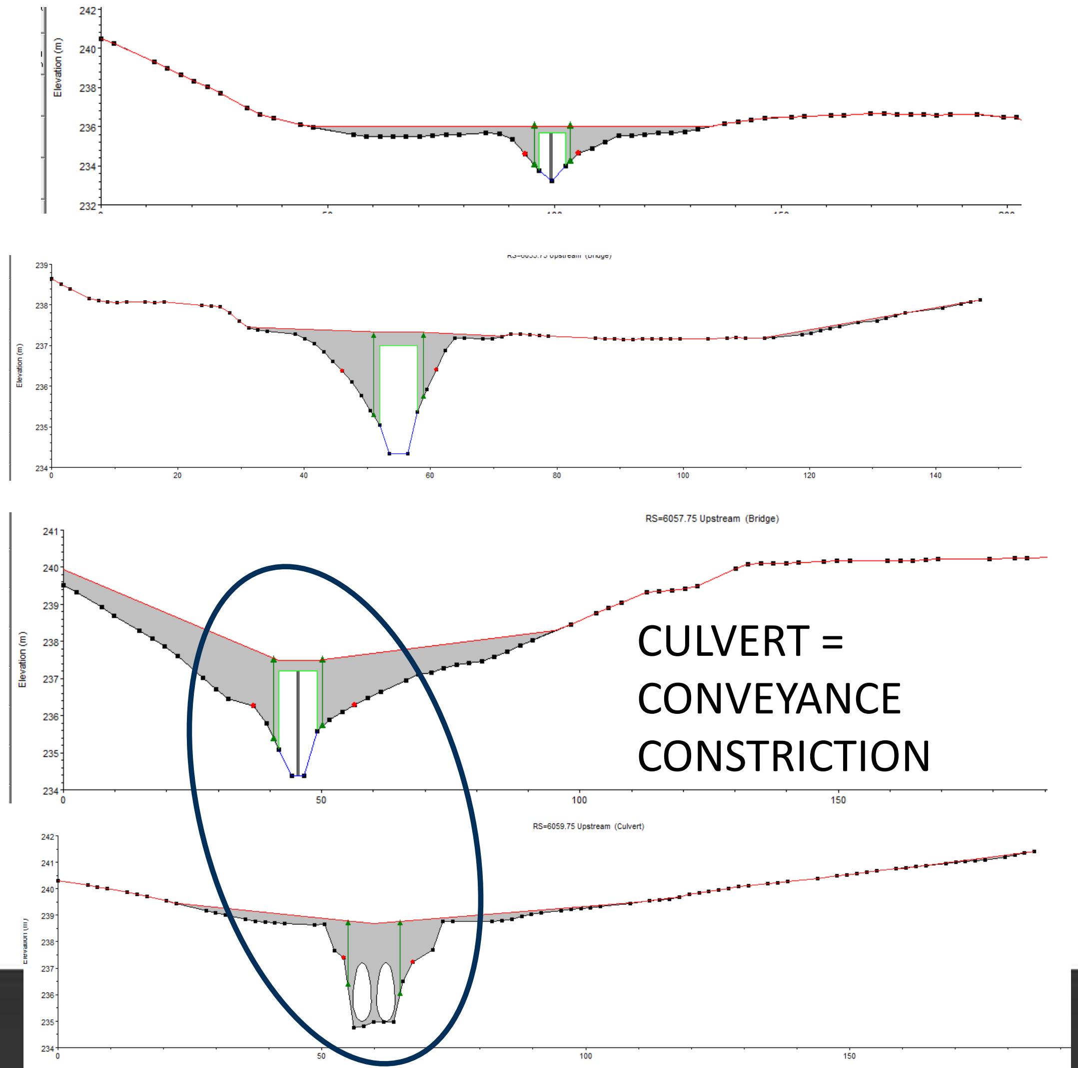


Stream depth: -3.60%

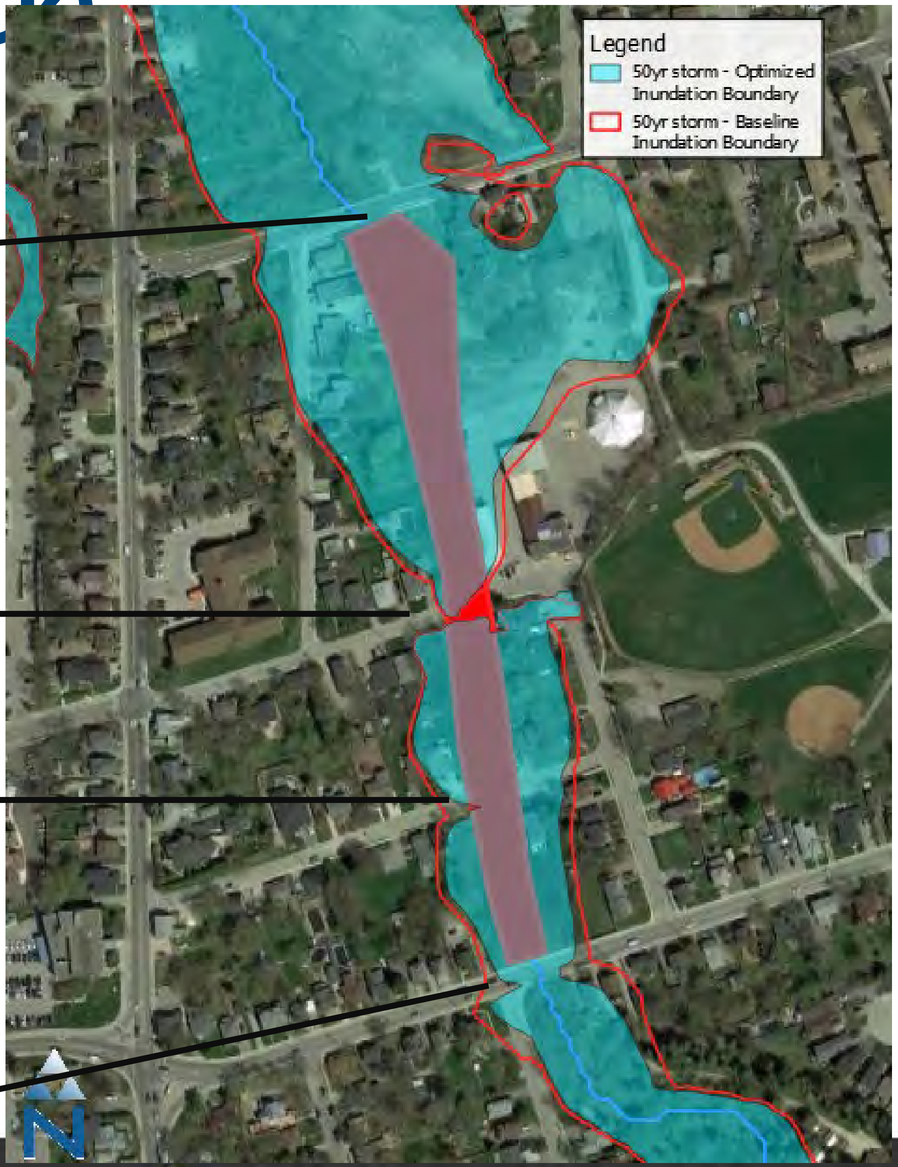
Conveyance Constriction Reduces Benefit of Peak Flow Reduction



Example Cross Sections in HEC-RAS
Area 8 (Newmarket, Bogart Ck)



CULVERT =
CONVEYANCE
CONSTRICTION



Simulating Benefit of SCM under Future Climate based on Flood Design Storms

- Future rainfall IDF curves under climate change extracted:
  - RCP 8.5: worst case
  - RCP 4.5: carbon emissions curbed
- The future storms were analyzed to forecast how much 'resiliency' the 40% TP reduction BMPs will build into the stormwater system

Site	2021-2050 RCP 4.5 10 yr			25 yr			100 yr		
	Non-Mitigated % Peak Flow Change	Mitigated % Peak Flow Change	Percent of Climate Change Mitigated	Non-Mitigated % Peak Flow Change	Mitigated % Peak Flow Change	Percent of Climate Change Mitigated	Non-Mitigated % Peak Flow Change	Mitigated % Peak Flow Change	Percent of Climate Change Mitgated
Area 2	+12.0%	-5.2%	100.0%	+46.9%	+30.4%	35.2%	+44.3%	+34.2%	22.8
Area 5	+20.4%	0.3%	98.5%	+33.3%	+14.2%	57.3%	+109.2%	+97.3%	10.9
Area 8	+11.4%	-11.4%	100.0%	+38.6%	+15.8%	59.2%	+90.7%	+75.8%	16.4
Area 10	+10.3%	-6.5%	100.0%	+31.5%	+15.3%	51.5%	+63.6%	+53.6%	15.8
Area 13	+11.4%	-11.7%	100.0%	+52.3%	+31.9%	39.1%	+55.5%	+44.5%	19.8
Area 14	+10.7%	-7.1%	100.0%	+32.0%	+14.3%	55.2%	+84.6%	+73.6%	13.0

Site	RCP 8.5 10 yr			25 yr			100 yr		
	Non-Mitigated % Peak Flow Change	Mitigated % Peak Flow Change	Percent of Climate Change Mitigated	Non-Mitigated % Peak Flow Change	Mitigated % Peak Flow Change	Percent of Climate Change Mitigated	Non-Mitigated % Peak Flow Change	Mitigated % Peak Flow Change	Percent of Climate Change Mitgated
Area 2	+18.0%	+0.8%	95.8%	+52.8%	+36.3%	31.3%	+33.2%	+23.0%	30.5
Area 5	+26.5%	+6.5%	75.7%	+38.1%	+19.1%	50.0%	+67.8%	+55.9%	17.6
Area 8	+15.9%	-7.0%	100.0%	+44.1%	+21.2%	51.8%	+58.5%	+43.7%	25.4
Area 10	+14.3%	-2.4%	100.0%	+35.7%	+19.5%	45.5%	+42.3%	+32.2%	23.8
Area 13	+17.5%	-5.6%	100.0%	+59.1%	+38.6%	34.6%	+40.0%	+28.1%	29.7
Area 14	+14.5%	-3.2%	100.0%	+36.5%	+18.8%	48.3%	+54.2%	+43.3%	20.3

Climate Change Mitigation by SCMs (2021-2050)

Qualified analysis of co-benefits

- Over 200 peer-reviewed studies informed the rating based on ‘capacity’ or ‘potential’ of a given SCM to provide a specific benefit.
- Rating scale: 0.0 to 1.0 – where ‘0.0’ is very low and ‘1.0’ is very high.
- A weighted qualitative evaluation of co-benefits comparing siting SCMs only on available public property (current practice) versus public + private property.

Rating*	Co-benefit Capacity or Potential
0	Very low potential or capacity to provide the co-benefit
¼	Limited or mediocre potential or capacity to provide the co-benefit
½	Medium or reasonable potential or capacity to provide the co-benefit
¾	High potential or capacity to provide the co-benefit
1	Very high potential to provide the co-benefit

* Qualitative rating based on the capacity of a SCM to provide co-benefits.

STORMWATER CONTROL MEASURE	CO-BENEFITS														
	Biodiversity	Habitat for species	Supports pollinators	Groundwater recharge & base flow	Erosion control	CO_2 sequestration & storage	Air quality Improvement	Drinking source water quality	Reduced Heat Stress	Energy savings	Improved aesthetics	Increased recreational opportunities	Increased Property Value	Reduced demand on infrastructure	AVERAGE RATING
Decentralized SCMs															
Bioretention	½	½	½	¾	¾	¾	½	¾	½	½	¾	½	½	½	0.59
Infiltration trench / chamber	0	0	0	1	½	¼	¼	½	¼	¼	¼	0	0	¼	0.25
Enhanced boulevard tree cell	½	½	½	¾	½	¾	¾	½	¾	½	¾	¼	½	½	0.57
Centralized SCMs															
Hybrid wetland/pond	¾	¾	¾	1	1	¾	½	1	¾	½	1	¾	¾	1	0.80

Study outcomes and findings

- **Demonstrated the multiple benefits** of undertaking watershed scale cost-optimization modeling.
- **Identified the most cost-effective opportunities** to achieve 40% phosphorus reductions in support of the LSPOP and the LSPP phosphorus reduction strategy’s target.
- **Demonstrated how the tool can be used to assess peak flow/ flood reduction** associated with P reduction control measures, the associated costs and damage reduction.
- **Developed a methodology** that can be further refined and applied to other watersheds within the Lake Simcoe basin and beyond.
- **Prepared critical datasets**, such as stormwater management lifecycle costs that can be readily applied to future studies.
- Ensured modeling was completed in **opensource (non-proprietary) software** facilitating flexibility in future application.

Implementation: Intermunicipal collaboration

Rationale:

- Reduced costs to individual municipalities, improved level of services and functions, expanded capacity, leveraging of resources and capabilities.

Policy & regulation:

- There are **no provincial or municipal policy or regulatory barriers** to intermunicipal collaboration for SWM.
- Multiple provinces, including Ontario, have specific **policies and programmes to encourage and support intermunicipal collaboration** on capital projects, operations and services.

Governance & administration:

- Multiple models in use for intermunicipal collaboration including, informal collaboration between two or more municipalities through to joint powers of agreement with formalized governance frameworks.

Implementation: Private property hosting of SCMs

Rationale:

- Meet targets, reduced costs, greater ability to target problem areas, long-term local economic stimulus and market development, increased property values, neighbourhood improvement, and greater ability to meet other environmental priorities (tree planting, biodiversity, UHI and air quality, etc.)

Policy & regulation:

- There are **no provincial or municipal policy or regulatory barriers** to private property hosting of centralized or distributed SCMs
- Multiple provinces, including Ontario, have specific **policies and programmes to encourage and support public-private partnerships.**

Governance & administration:

- Multiple mechanisms including joint ventures, municipally administered market-based incentives, third-party management/delivery, combination of municipal-third-party management.

Next steps

- Establish a **senior-level working group**, possibly an extension of the existing study Technical Advisory Committee (TAC), to develop a work plan and strategy for the implementation of system-wide SWM and public-private projects.
- **Meet with senior municipal staff, council, industry/sector representatives** and **First Nations** to discuss findings and explore opportunities for support and collaboration.
- **Develop guidance and training materials** and tools to support area municipalities in the use of optimization analysis for SWM planning.
- Evaluate the application of **system-wide SWM principles Lake Simcoe-wide**
- Evaluate **integrating the use of non-structural SCMs and natural assets** as integral parts of the SWM system

Acknowledgements

TECHNICAL ADVISORY COMMITTEE MEMBERS

Municipalities

- York Region
- Town of Newmarket
- Town of Aurora
- Town of East Gwillimbury
- Town of Whitchurch-Stouffville

Conservation Authorities

- Toronto Region
- Credit Valley
- Lake Simcoe

Provincial Government

- Ministry of Environment, Conservation & Parks

Consultants

- Freeman Associates Ltd.
- Paradigm Environmental
- Fortin Economics
- Barry Hassler

Funding Partners

- Federation of Canadian Municipalities (FCM)
- Natural Resources Canada (NRCAN)
- National Disaster Mitigation Program (NDMP)
- York Region
- Lake Simcoe Conservation Foundation
- Toronto Region Conservation Authority (TRCA)
- Credit Valley Conservation (CVC)
- Town of Newmarket

QUESTIONS AND DISCUSSION

Contact information

Ben Longstaff

General Manager, Integrated Watershed Management
Lake Simcoe Region Conservation Authority
b.longstaff@LSRCA.on.ca | www.LSRCA.on.ca

Dustin Bambic

Director, Paradigm Environmental
dustin.bambic@paradigmh2o.com| www.paradigmh2o.com

Tracy Patterson

Principal, Freeman Associates Ltd
Email. tracy@thewaterstrategy.com
www.thewaterstrategy.com

Thank you