Green Rainwater Infrastructure Pathways Study

Scope and Findings Summary (2024)

This place is the unceded and ancestral homelands of the xʷməθkʷəy̓əm (Musqueam), Sḵwx̱wú7mesh (Squamish), and səl̓ilwətaʔɬ (Tsleil-Waututh) nations (MST) and has been traditionally stewarded by them since time immemorial.

Green Rainwater Infrastructure Pathways Study

Study Purpose

To understand:

- what **GRI tool** combinations ("pathways") – e.g. green roof, ground infiltration, tank, water re-use, other - are most suitable to meet the Rain City Strategy (RCS) performance **targets** for various representative building-site **typologies** (e.g. small lot, low-rise, mid-rise, high-rise, other) on private property.
- the **capital costs** of GRI tools and tool combinations,
- **co-benefits** (e.g. urban heat mitigation, groundwater recharge, twelve others),
- implementation **barriers**, and potential **solutions**.

Green Rainwater Infrastructure Pathways Study

Agenda

- Purpose.
- Rainwater context.
- Project overview.
- Departments, partners, and stakeholders.
- Timeline and Deliverables.
- Tasks 2 to 9. Workshops.
- Study Findings and Observations.
- Study Recommendations.

Rainwater Context

The city was once a
temperate rainforest.

Image: Capilano River Regional Park, North Vancouver
Photo Credit: Robert Pennings

Over time, we have changed the **natural watersheds…**

(sanitary & stormwater are collected, combined, concentrated, and conveyed away from where they originate)

Image: View of Yaletown from Charleson Park in 1893, Vancouver
Photo Credit: www.onthisspot.ca, 10/25/2015

...to service today's **Vancouver.**

…to service today’s **Vancouver**.

- Combined system near capacity
- CSO’s, aquatic pollution
- Climate change, future growth
- Replacement and upgrade costs

City Responses

- **City-wide Integrated Rainwater Management Plan, Rain City Strategy, Healthy Waters Plan and Groundwater Strategy all to align with City goals around:**
  - Climate Adaptation, Vancouver Plan Ecological Vision, delivery of housing, provision of affordable sewage and drainage services.

Rain City Strategy Vision

Vancouver's rainwater is embraced as a valued resource for our communities and natural ecosystems.

Image: Vancouver skyline
Photo Credit: Wendy de Hoog

GRI Pathways Study Project Overview

1. 7 'Building-Site' **Typologie**s that represent CoV building stock

2. GRI Tools - infiltration, blue/green roofs, water reuse

Design methodologies

24mm/day & 48mm/day

3a. Model/ rank GRI tool 'pathways' that meet Bulletin – site, policy, and form & massing assumptions

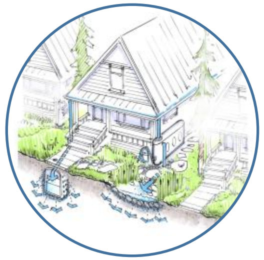
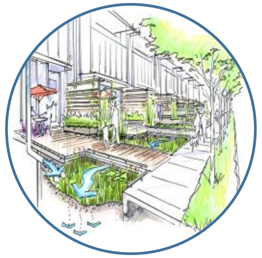
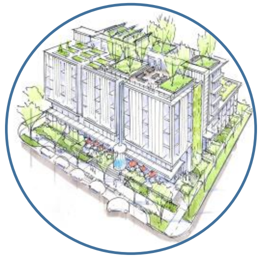
3b. Broadway zero discharge

4. Understand Pathway **Costs** and rank **Co-benefits** of GRI tool combinations

5. Understand **Barriers and Solutions** to GRI implementation

Develop **Policy considerations –** recommended pathways, policy barriers, risk mitigation, **Policy Implementation, Standards, Toolkits, Capacity building**

GRI tool combinations best suited to building types? (example only)

		Single Family	Mid-Rise	High-Rise
	Capture and Re-use		✓	✓
	Infiltration	✓	✓	
	Resilient Roofs		✓	✓

Which Departments Were Involved?

Which Partners & Stakeholders Were Involved?

GRI Pathways Study: Project Timeline

Section 1
Typologies & Tools

- Representative Building-Site Typologies
- Rainwater Management Tools

Section 2
Design Standards, Modeling, Costs

- GRI Design Methodology
- Performance Modeling
- Pathway Development
- Cost Estimates

Section 3
Benefits, Barriers, & Solutions

- Values and Co-Benefits
- Implementation Barriers
- Solutions to Barriers

Section 4
Policy Considerations

- Pathway Findings
- Policy Options
- Implementation Recommendations

Workshop #1
Typologies, Tools, & Barriers Identification

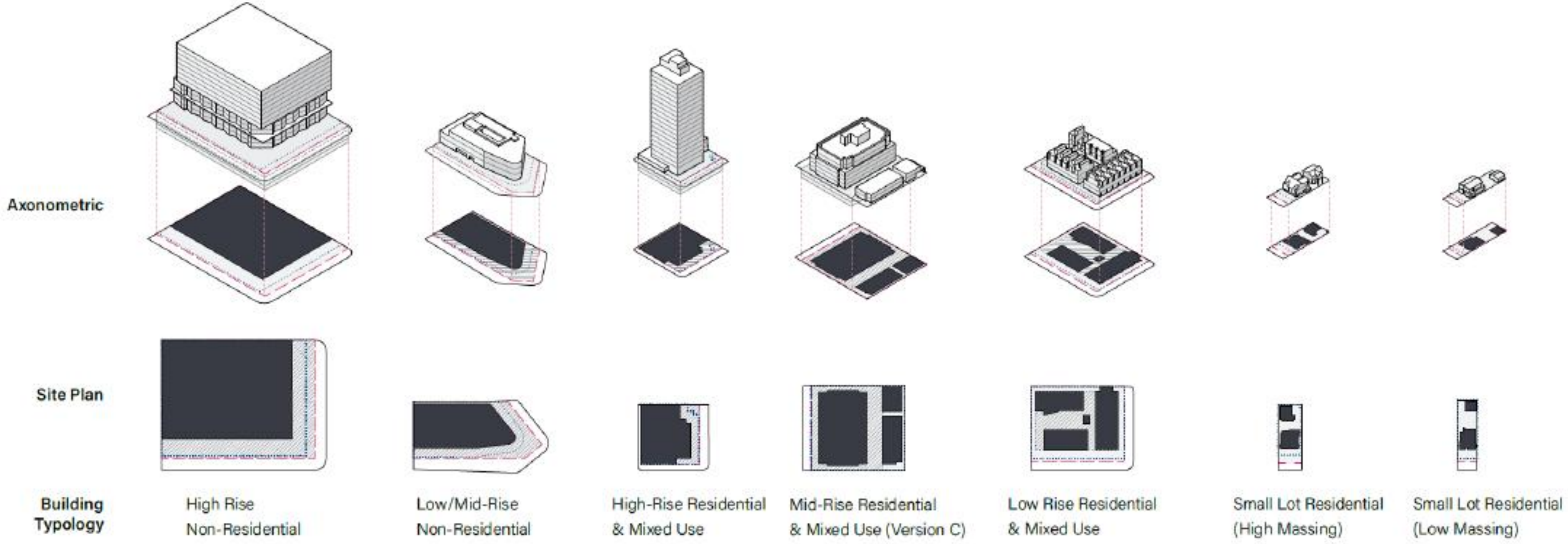
Workshop #2
Green Roofs

Workshop #3
Findings, Policy Considerations, & Next Steps

GRI Pathways Study: Deliverables

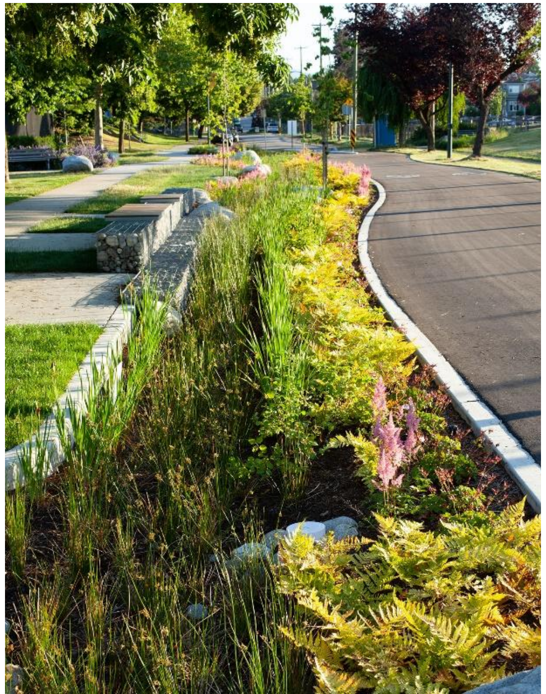
- **The GRI Pathways Study included a series of 9 major tasks.**
  - Task 1 – Confirm Work Plan.
  - Task 2 – Representative Building-Site Typologies.
  - Task 3 – Rainwater Management Tools.
  - Task 4 – GRI Design Methodology.
  - Task 5 – Performance Modeling and Solution Sets ("Pathways").
  - Task 6 – Costing.
  - Task 7 – Co-Benefits.
  - Task 8 – Barriers and Solutions.
  - Task 9 – Policy Considerations.

Task 2 - Representative Building Site Typologies



Task 3 - Rainwater Management Tools

- **Tier 1 and Tier 2* Tools (not exhaustive)**
  - Resilient (green) roof, Bioretention (unlined, lined*).
  - Absorbent landscapes (over soil, slab*), Tree trench.
  - Permeable pavement (as is, lined w underdrains*).
  - Subsurface infiltration (drywells, drill drains, etc.).
  - Non-potable water reuse.
- **Tier 3 Tools**
  - Detention tank (surface, subsurface, blue roof).
  - Water quality treatment device (e.g. Jellyfish filter).



Task 4 – GRI Design Methodology

- **GRI Design Methodology and Design Tool**
    - Current state assessment.
    - Review of historic rainwater management plans.
    - Jurisdictional scan (Toronto, North Vancouver, Portland, Seattle, San Francisco, Philadelphia, Washington, D.C.).
    - Current GRI design methodology.
    - Recommended GRI design methodology.
    - GRI design tool development.

Task 5 – Performance Modeling and Solution Sets

- **Objective**: Determine individual and combined **GRI tool performance** and **viability** for each building-site typology.
- Completed over two phases:
  - Phase 1 (during Task 5).
  - Phase 2 (during Task 9).

Phase 1

- **Targets**: Achieve 24-mm and 48-mm/ day volume reduction through retention; water quality (80% TSS); release rate (Qpost <= Qpre).
- **Site Conditions**:
  - Develop **modeling variables** to reflect a range of physical and regulatory conditions
  - (→ see next slide).

Task 5 – Performance Modeling and Solution Sets

Table ES 2 - Summary of Modeling Variables				
(1) Retention Design Standard	(2) Site Conditions		(3) Development and Policy Conditions	
	Pre-Development Condition	Soil Infiltration Rate	Infiltration Area	Non-potable Water Reuse
• 24 mm/ day • 48 mm/ day	• No pre-development (natural conditions, 0% impervious) • Less than post-development (50% of typology impervious) • Equivalent to post-development (100% of typology impervious)	• High (50 mm/hr) • Medium (20 mm/hr) • Low (5 mm/hr) • No (0 mm/hr)	No Infiltration setback (building foundation) • Standard (5 m) • Reduced (3 m) • None (0 m) Parkade extents • Min (occupies only building footprint) • Max (occupies 90 - 100% of parcel)	• Typical non-potable demands (flushing + irrigation) • Expanded non-potable demands (including clothes washing and cooling makeup)

Task 5 – Performance Modeling and Solution Sets

- **Phase 1**
  - **73,000+** modeling scenarios. ***Appendix A – Typology Modelling Result Dashboards***.
  - **Prelim Findings**: Achieved 24 and 48 mm/day targets for <u>many</u> scenarios, especially under favourable site conditions.
  - Most typologies do have some conditions when 24 and/ or 48 mm/day is not possible.
  - Target feasibility influenced by infiltration 'area' (setback, parkade) and 'rate' (soil).
- **Setback** (5m → 3m): Substantial gains. Enables all typologies to achieve 48 mm/day (except the 'no infiltration' condition).
- **Setback** (3m → 0m): Little to no gains.

- **Phase 2 (during Task 9)**
  - **Objective**: Augment <u>subset of Task 5</u> modeling findings with **Task 6** (cost) and **Task 7** (co-benefits) to optimize GRI solution sets for each building typology.

Task 6 – Costing

- **Capital Costs – GRI Tools**
  - Planning-level (AACE Class 5 estimate) unit capital costs for each **GRI tool** (reflective of Vancouver context).
- **Capital Costs – GRI Solution Sets (compliance pathways)**
  - Planning-level total capital cost estimates for **GRI pathways** related to each building-site typology.
- **Costs - Relative to Building and Maintenance**
  - Total capital costs for each GRI pathway as a **percentage** of overall building construction cost.
  - **Qualitative** evaluation of the O&M cost for each pathway.

Task 7 – Co-Benefits

- Consultant used a 5-Star rating scale to approximate solution set (pathway) co-benefits:

Benefit	Criteria	Metric
Economic	Life cycle considerations	Ease of O&M
		Replacement frequency
	Property values	Property value uplift
	Energy efficiency	Energy savings
	Other cost implications	Other costs
Environmental	Ecosystem health	Biodiversity and habitat enhancement
	Water preservation	Potable water savings
	Water resource restoration	Groundwater recharge
	Climate	Carbon sequestration
Community	Community health	Air quality improvement
		Urban heat island mitigation
		Provides or enhances access to nature
Resiliency	Long-term stresses (e.g. climate change)	Adaptability
	Short-term stresses and shocks (e.g. earthquake)	Service disruption potential

Task 8 - Barriers and Solutions

Category	Barriers (real or perceived)	Solutions
Physical	• Steep Topography • Soil or Groundwater Contamination • High Groundwater or Bedrock • Low or Zero Infiltration Capacity • Existing Trees (Root Protection Zones) • Inadequate or Shallow Municipal Service Connection	• GRI Design Standards and Manual • Alternative Compliance Program
Regulatory	• Rooftop Space Constraints and Competition • Building Envelope Certification and Building Insurance • Maximizing Development within Zoning By-law, Parking, and Other Policies • Building Integrity Concerns • Challenges with Managing Runoff Across Property Lines • Rainwater Harvesting Feasibility and Cost Effectiveness	• GRI Design Standards and Manual • Resilient Roofs Policy • Potable water savings • Groundwater recharge • Expand alternative water sources allowed (reuse) • Alternative Compliance Program, other
Procedural	• Lack of Departmental Coordination • Unclear RWMP Submission Process • Lack of GRI Maintenance Plan Enforcement	• GRI Design Guidance Coordination • GRI Maintenance Standards and Enforcement
Economic	• Added Incremental Costs • Affordability of Housing	• GRI Design Standards and Manual • Alternative Compliance Program
Cultural	• Limited Local GRI Design Expertise • Insufficient GRI Construction Standards and Expertise • Limited Understanding of Benefits and Costs • Perception of Higher Risk	• GRI Engagement and Training • Providing Leadership

Task 9 - Policy Considerations

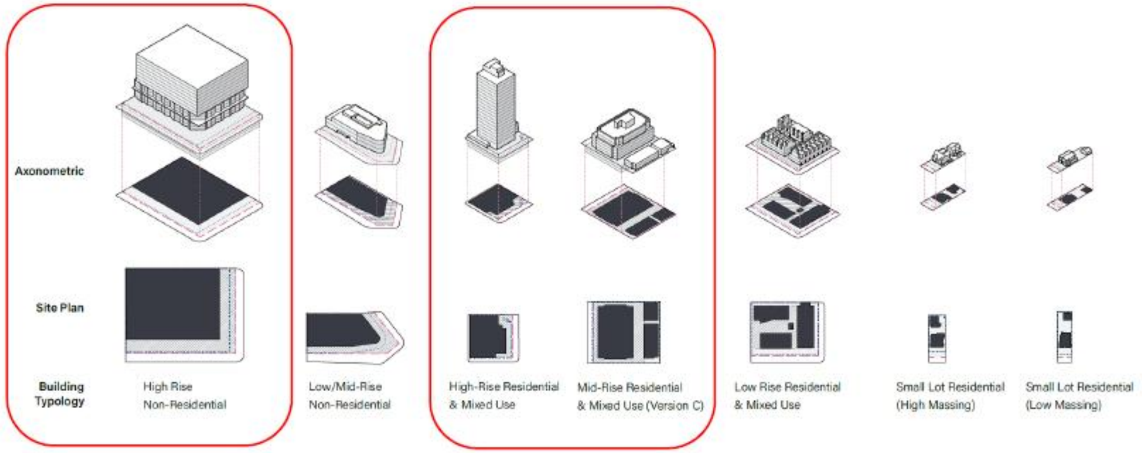
- **Section 1 - Pathway Solution Sets and Release Rate Analysis**
  - Inclusion of costing, co-benefits → Solution sets for 24mm, 48mm/ day.
  - Pathways organized into 5 categories (Summary Table ES 7), key takeaways, observations.
- **Section 2 - Policy Options and Recommendations**
  - Recommendations for alignment with citywide HWP, determining 'performance-based' (vs 'prescriptive') standard, release rate reduction.
- **Section 3 – Implementation Steps**
  - Recommendations for specific GRI types, policy implementation, and interim steps.

Workshops - Objectives

- **Workshop 1 – Typologies, Tools, and Implementation Barriers**
  - Introduce GRI Pathways Study **objectives**, proposed **typologies** and **tools.**
  - Implementation **barriers** identified to date. Obtain feedback.
- **Workshop 2 – Barriers and Solutions for Green Roofs**
  - Obtain feedback from subject matter experts, industry leaders, advocates, and stakeholders about green roof benefits and **implementation barriers**.
  - Categories include: policy, design, installation, maintenance, and regulation.
- **Workshop 3 – Findings, Policy Considerations, and Next Steps**
  - Provide an overview of work to date, including **co-benefits**, and discuss preliminary policy **considerations** to support the implementation of GRI. Also see **Engagement Summaries**.

Study Findings – 24 mm – exploring limiting conditions

1. When ground infiltration is not possible
   - **Viable (3)**: GFA>10,000 m2: Mid (& High)-rise residential & mixed use (6 storey,(20)), High-rise non-resid (14). (green roof, water reuse).
   - **Not viable (4)(50%)**: Small lot resid-low (& high) (2), Low rise resid and mixed use (3), Low/mid-rise non-residential (3).



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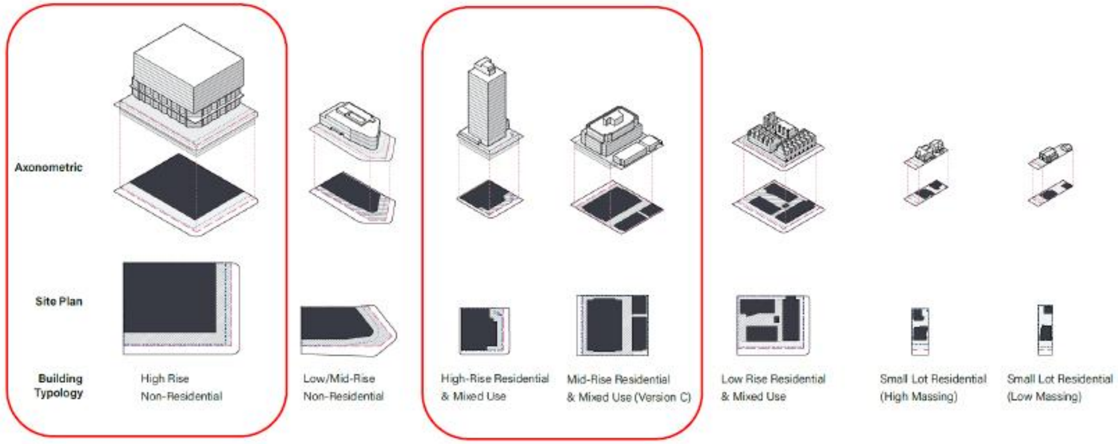
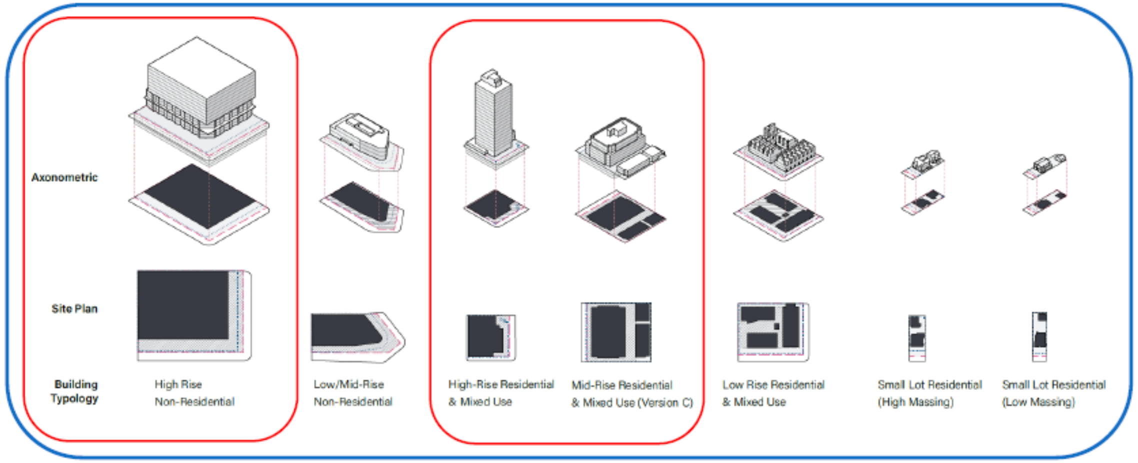


2. **When ground infiltration possible (5mm/hr)**
   - **Viable (6)**: plus, the 3 smaller typologies (green roof, bioretention planters, pavers).
   - **Not viable (1)**: Low/mid-rise non-residential (3). Viable with reduced setback/ parkade.

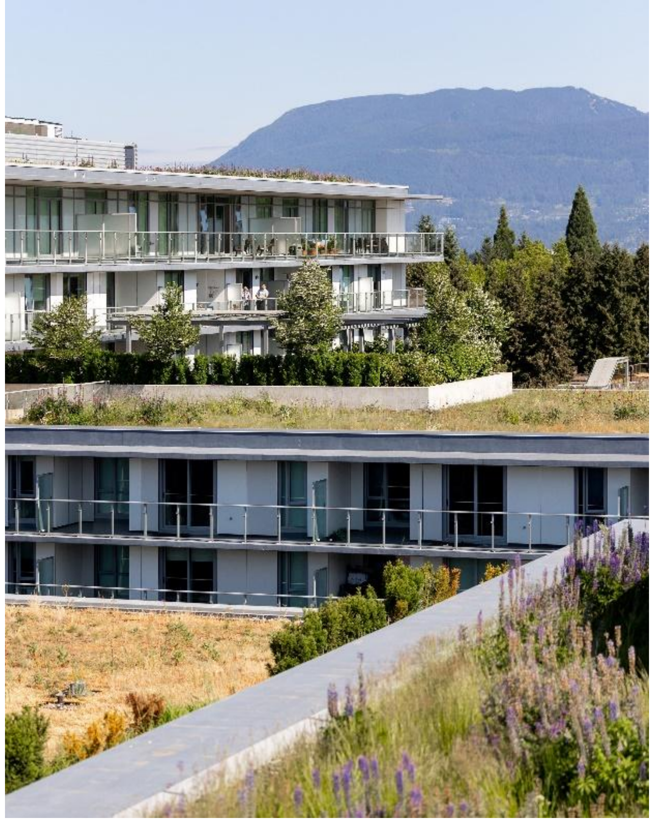


Study Findings – 48 mm – exploring limiting conditions

1. When ground infiltration is not possible
    - **Viable (0)**: No building types.
    - **Not viable (7)**: All building types.
2. When ground infiltration possible (5mm/hr)
    - **Viable (3)**: Small lot res-low (& high), High-rise residential & mixed use (20).

    (green roof, bioretention, sub infiltration).

    - **Not viable (4)**: Other types. All viable with reduced setback/ parkade (5m → 3m).

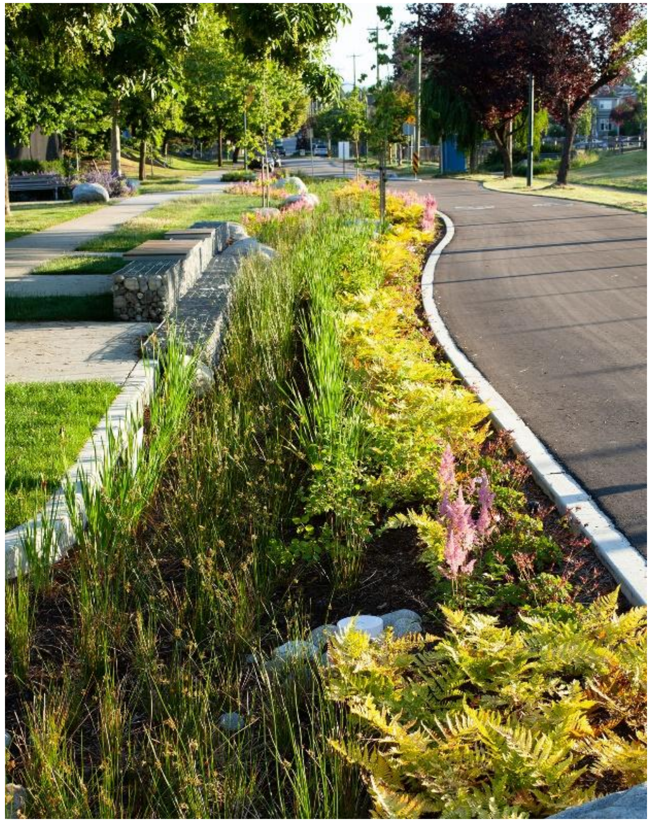


Study Findings – 48 mm – exploring limiting conditions

1. **When ground infiltration is not possible**
   - **Viable (0)**: No building types.
   - **Not viable (7)**: All building types.
2. **When ground infiltration possible (5mm/hr)**
   - **Viable (3)**: Small lot res-low (& high), High-rise residential & mixed use (20).

   (green roof, bioretention, sub infiltration).

   - **Not viable (4)**: But, all are viable with reduced setback/ parkade (5m → 3m).



Study Findings – general impacts to project costs

1. **When ground infiltration is not possible**
   - **Viable (0)**: No building types.
   - **Not viable (7)**: All building types.
2. **When ground infiltration possible (5mm/hr)**
   - **Viable (3)**: Small lot res-low (& high), High-rise residential & mixed use (20).

   (green roof, bioretention, sub infiltration).

   - **Not viable (4)**: But, all are viable with reduced setback/ parkade (5m → 3m).

General Impacts to Project Capital Costs

- **Cat 1, 2, 4:**
  - increased 1-3% over conventional approach (detention tank, water quality treatment).
- **Cat 3*:**
  - increased < 1% over conventional approach.

*Excludes any potential costs related to reduced setback.

Example – gains from a reduced setback (current 5m)

48mm Mid-Rise

Current Conditions

Mid-Rise Residential & Mixed-Use

Performance Modeling Summary (48 mm)

Typology	Mid-Rise Residential & Mixed-Use
Standard	48 mm Retention
Parkade Extent	Full Extent of Impervious Area
Setback Policy	Existing Setback (5m)

Scenarios with compliant pathways	2/20

Percent of Total Surface Type Runoff Volume Managed by Tool in Isolation

0% Managed with Resilient Roof

Infiltration Scenario	Surface Type	Existing Area (m2)	Rainwater harvesting	Permeable pavement	Bioretention	Subsurface infiltration
No Infiltration	Impervious - Roof	1,950	30%	0%	0%	0%
	Impervious - Ground	900	64%	0%	0%	0%
	Pervious	150			5%	0%
	All Surface Types Tributary to GRI		20%	0%	0%	0%
	Compliant Pathway Available?		No			
Low Infiltration	Impervious - Roof	1,950	30%	0%	12%	10%
	Impervious - Ground	900	64%	0%	25%	22%
	Pervious	150			100%	100%
	All Surface Types Tributary to GRI		20%	0%	8%	7%
	Compliant Pathway Available?		No			
Moderate Infiltration	Impervious - Roof	1,950	30%	0%	21%	14%
	Impervious - Ground	900	64%	0%	45%	30%
	Pervious	150			100%	100%
	All Surface Types Tributary to GRI		20%	0%	14%	9%
	Compliant Pathway Available?		No			
High Infiltration	Impervious - Roof	1,950	30%	0%	39%	21%
	Impervious - Ground	900	64%	0%	80%	46%
	Pervious	150			100%	NA
	All Surface Types Tributary to GRI		20%	0%	27%	14%
	Compliant Pathway Available?		No			

25% Managed with Resilient Roof

Infiltration Scenario	Surface Type	Rainwater harvesting	Permeable pavement	Bioretention	Subsurface infiltration
No Infiltration	Impervious - Roof	40%	0%	0%	0%
	Impervious - Ground	64%	0%	0%	0%
	Pervious			5%	0%
	All Surface Types Tributary to GRI	24%	0%	0%	0%
	Compliant Pathway Available?	No			
Low Infiltration	Impervious - Roof	40%	0%	15%	13%
	Impervious - Ground	64%	0%	25%	22%
	Pervious			100%	100%
	All Surface Types Tributary to GRI	24%	0%	9%	8%
	Compliant Pathway Available?	No			
Moderate Infiltration	Impervious - Roof	40%	0%	28%	18%
	Impervious - Ground	64%	0%	45%	30%
	Pervious			100%	100%
	All Surface Types Tributary to GRI	24%	0%	17%	11%
	Compliant Pathway Available?	No			
High Infiltration	Impervious - Roof	40%	0%	52%	28%
	Impervious - Ground	64%	0%	80%	46%
	Pervious			100%	NA
	All Surface Types Tributary to GRI	24%	0%	32%	17%
	Compliant Pathway Available?	No			

50% Managed with Resilient Roof

Infiltration Scenario	Surface Type	Rainwater harvesting	Permeable pavement	Bioretention	Subsurface infiltration
No Infiltration	Impervious - Roof	59%	0%	0%	0%
	Impervious - Ground	64%	0%	0%	0%
	Pervious			5%	0%
	All Surface Types Tributary to GRI	31%	0%	0%	0%
	Compliant Pathway Available?	No			
Low Infiltration	Impervious - Roof	59%	0%	23%	20%
	Impervious - Ground	64%	0%	25%	22%
	Pervious			100%	100%
	All Surface Types Tributary to GRI	31%	0%	12%	10%
	Compliant Pathway Available?	No			
Moderate Infiltration	Impervious - Roof	59%	0%	42%	27%
	Impervious - Ground	64%	0%	45%	30%
	Pervious			100%	100%
	All Surface Types Tributary to GRI	31%	0%	21%	14%
	Compliant Pathway Available?	No			
High Infiltration	Impervious - Roof	59%	0%	78%	42%
	Impervious - Ground	64%	0%	80%	46%
	Pervious			100%	NA
	All Surface Types Tributary to GRI	31%	0%	40%	22%
	Compliant Pathway Available?	No			

75% Managed with Resilient Roof

Infiltration Scenario	Surface Type	Rainwater harvesting	Permeable pavement	Bioretention	Subsurface infiltration
No Infiltration	Impervious - Roof	100%	0%	1%	0%
	Impervious - Ground	64%	0%	0%	0%
	Pervious			5%	0%
	All Surface Types Tributary to GRI	42%	0%	0%	0%
	Compliant Pathway Available?	No			
Low Infiltration	Impervious - Roof	100%	0%	46%	40%
	Impervious - Ground	64%	0%	25%	22%
	Pervious			100%	100%
	All Surface Types Tributary to GRI	42%	0%	16%	14%
	Compliant Pathway Available?	No			
Moderate Infiltration	Impervious - Roof	100%	0%	83%	55%
	Impervious - Ground	64%	0%	45%	30%
	Pervious			100%	100%
	All Surface Types Tributary to GRI	42%	0%	29%	19%
	Compliant Pathway Available?	No			
High Infiltration	Impervious - Roof	100%	0%	100%	84%
	Impervious - Ground	64%	0%	80%	46%
	Pervious			100%	NA
	All Surface Types Tributary to GRI	42%	0%	53%	30%
	Compliant Pathway Available?	No			

100% Managed with Resilient Roof

Infiltration Scenario	Surface Type	Rainwater harvesting	Permeable pavement	Bioretention	Subsurface infiltration
No Infiltration	Impervious - Roof	NA	NA	NA	NA
	Impervious - Ground	64%	0%	0%	0%
	Pervious			5%	0%
	All Surface Types Tributary to GRI	64%	0%	0%	0%
	Compliant Pathway Available?	No			
Low Infiltration	Impervious - Roof	NA	NA	NA	NA
	Impervious - Ground	64%	0%	25%	22%
	Pervious			100%	100%
	All Surface Types Tributary to GRI	64%	0%	24%	21%
	Compliant Pathway Available?	No			
Moderate Infiltration	Impervious - Roof	NA	NA	NA	NA
	Impervious - Ground	64%	0%	45%	30%
	Pervious			100%	100%
	All Surface Types Tributary to GRI	64%	0%	43%	29%
	Compliant Pathway Available?	Yes			
High Infiltration	Impervious - Roof	NA	NA	NA	NA
	Impervious - Ground	64%	0%	80%	45%
	Pervious			100%	NA
	All Surface Types Tributary to GRI	64%	0%	78%	45%
	Compliant Pathway Available?	Yes			

Example – gains from a reduced setback (5m → 3m)

48mm Mid-Rise

Modified Setback (3m) + Reduced Parkade

Mid-Rise Residential & Mixed-Use

Performance Modeling Summary (48 mm, Modified Setback + Reduced Parkade)

Typology	Mid-Rise Residential & Mixed-Use
Standard	48 mm Retention
Parkade Extent	Full Building Footprint or NA
Setback Policy	Modified Setback (3m)

Scenarios with compliant pathways	15/20

Percent of Total Surface Type Runoff Volume Managed by Tool in Isolation

Infiltration Scenario	Surface Type	Existing Area (m2)	0% Managed with Resilient Roof				25% Managed with Resilient Roof				50% Managed with Resilient Roof				75% Managed with Resilient Roof				100% Managed with Resilient Roof			
			Rainwater harvesting	Permeable pavement	Bioretention	Subsurface infiltration	Rainwater harvesting	Permeable pavement	Bioretention	Subsurface infiltration	Rainwater harvesting	Permeable pavement	Bioretention	Subsurface infiltration	Rainwater harvesting	Permeable pavement	Bioretention	Subsurface infiltration	Rainwater harvesting	Permeable pavement	Bioretention	Subsurface infiltration
No Infiltration	Impervious - Roof	1,950	30%	0%	0%	0%	40%	0%	1%	0%	59%	0%	1%	0%	100%	0%	2%	0%	NA	NA	NA	NA
	Impervious - Ground	900	64%	0%	1%	0%	64%	0%	1%	0%	64%	0%	1%	0%	64%	0%	1%	0%	64%	0%	1%	0%
	Pervious	150			9%	0%			9%	0%			9%	0%			9%	0%			9%	0%
	All Surface Types Tributary to GRI		20%	0%	0%	0%	24%	0%	0%	0%	31%	0%	0%	0%	42%	0%	1%	0%	64%	0%	1%	0%
	Compliant Pathway Available?		No				No				No				No				No			
Low Infiltration	Impervious - Roof	1,950	30%	100%	34%	100%	40%	100%	45%	100%	59%	100%	68%	100%	100%	100%	100%	100%	NA	NA	NA	NA
	Impervious - Ground	900	64%	100%	73%	100%	64%	100%	73%	100%	64%	100%	73%	100%	64%	100%	73%	100%	64%	100%	73%	100%
	Pervious	150			100%	100%			100%	100%			100%	100%			100%	100%			100%	100%
	All Surface Types Tributary to GRI		20%	100%	22%	100%	24%	100%	27%	100%	31%	100%	34%	100%	42%	100%	45%	100%	64%	100%	67%	100%
	Compliant Pathway Available?		Yes				Yes				Yes				Yes				Yes			
Moderate Infiltration	Impervious - Roof	1,950	30%	100%	61%	100%	40%	100%	81%	100%	59%	100%	100%	100%	100%	100%	100%	100%	NA	NA	NA	NA
	Impervious - Ground	900	64%	100%	100%	100%	64%	100%	100%	100%	64%	100%	100%	100%	64%	100%	100%	100%	64%	100%	100%	100%
	Pervious	150			100%	100%			100%	100%			100%	100%			100%	100%			100%	100%
	All Surface Types Tributary to GRI		20%	100%	40%	100%	24%	100%	48%	100%	31%	100%	60%	100%	42%	100%	80%	100%	64%	100%	100%	100%
	Compliant Pathway Available?		Yes				Yes				Yes				Yes				Yes			
High Infiltration	Impervious - Roof	1,950	30%	100%	100%	100%	40%	100%	100%	100%	59%	100%	100%	100%	100%	100%	100%	100%	NA	NA	NA	NA
	Impervious - Ground	900	64%	100%	100%	100%	64%	100%	100%	100%	64%	100%	100%	100%	64%	100%	100%	100%	64%	100%	100%	100%
	Pervious	150			100%	NA			100%	NA			100%	NA			100%	NA			100%	NA
	All Surface Types Tributary to GRI		20%	100%	73%	100%	24%	100%	85%	100%	31%	100%	98%	100%	42%	100%	100%	100%	64%	100%	100%	100%
	Compliant Pathway Available?		Yes				Yes				Yes				Yes				Yes			

Example – gains from a reduced setback – cost comparison

Building Typology	No Infiltration (Zero Lot-Line Setback / Parkade Condition)	CATEGORY 2: Low Infiltration (5 mm/hr) and Standard Setback/Parkade Conditions. 24 mm/day.				CATEGORY 3: Low Infiltration (5 mm/hr) and Reduced Setback/Parkade Conditions. 24 mm/day.			
		GRI Tools	Impact on Construction Cost (compared to detention)	Qualitative O&M Cost	Co-Benefit Score	GRI Tools	Impact on Construction Cost (compared to detention)	Qualitative O&M Cost	Co-Benefit Score
Small Lot Residential – Low Massing	*No viable pathway*	• Bioretention	-3.6%	Medium/High	★★	• Bioretention	-3.6%	Medium	★★★★
Small Lot Residential – High Massing	*No viable pathway*	• Green Roof • Bioretention • Permeable Pavement	+3.1%	Medium/High	★★★	• Bioretention	-0.9%	Medium	★★★★
Low-Rise Residential & Mixed-Use	*No viable pathway*	• Green Roof • Bioretention	+2.5%	Medium/High	★★★	• Bioretention	+0.8%	Medium	★★★★
Mid-Rise Residential & Mixed-Use	• Green Roof • Rainwater Harvesting	• Green Roof • Rainwater Harvesting • Bioretention	+1.3%	High	★★	• Bioretention • Permeable Pavement	+0.2%	Medium	★★★
High-Rise Residential & Mixed-Use	• Rainwater Harvesting	• Green Roof • Bioretention	+0.2%	Medium/High	★★★	• Bioretention	+0.1%	Medium	★★★★
Low/Mid-Rise Non-Residential	*No viable pathway*	*No viable pathway (parkade occupies entire site)*	+1.5-3.4%	High	★★★	• Bioretention • Permeable Pavement	+0.2%	Low/Medium	★★★
High-Rise Non-Residential	• Green Roof • Rainwater Harvesting	• Green Roof • Rainwater Harvesting	+1.2%	High	★★	• Bioretention • Permeable Pavement	+0.1%	Medium	★★★

Study Findings - summary table – pathways solution sets

Pathway Category	1	2	3	4
Retention	**24 mm**			**48 mm**
Infiltration potential	**No infiltration**	**Low infiltration (5 mm/hr)**		
Setback	**n/a**	**Standard setback (5m)/ full parkade**	**Reduced Setback (3m)/ reduced Parkade**	
Small Lot Residential – Low Massing	*No viable pathway*	• Bioretention	• Bioretention	• Bioretention
Small Lot Residential – High Massing	*No viable pathway*	• Green Roof • Bioretention • Permeable Pavement	• Bioretention	• Green Roof • Subsurface Infiltration
Low-Rise Residential & Mixed-Use	*No viable pathway*	• Green Roof • Bioretention	• Bioretention	• Bioretention • Permeable Pavement
Mid-Rise Residential & Mixed-Use	• Green Roof • Rainwater Harvesting	• Green Roof • Rainwater Harvesting • Bioretention	• Bioretention • Permeable Pavement	• Green Roof • Subsurface Infiltration
High-Rise Residential & Mixed-Use	• Rainwater Harvesting	• Green Roof • Bioretention	• Bioretention	• Bioretention • Permeable Pavement
Low/Mid-Ride Non-Residential	*No viable pathway*	*No viable pathway*	• Bioretention • Permeable Pavement	• Green Roof • Bioretention • Permeable Pavement
High-Rise Non-Residential	• Green Roof • Rainwater Harvesting	• Green Roof • Rainwater Harvesting	• Bioretention • Permeable Pavement	• Green Roof • Bioretention • Permeable Pavement

Study Observations

1. Three typologies* can meet 24 mm retention target with no need for infiltration.

- Mid-rise residential/mixed, high-rise res/mixed, and high-rise non-res.

*Due to sufficient non-potable demand.

2. The policy that best facilitates cost effective GRI and increased retention target feasibility:

- Create more space for infiltration though foundation **setback** reduction (5m to 3m), and/ or reduced parkade extents.

3. Meeting retention targets is most challenging and expensive **when infiltration is not possible**.

- Water reuse systems are then required to manage at-grade runoff.
- Only larger, dense buildings have sufficient daily indoor **non-potable demand** to make water reuse a feasible tool.

4. At time of study, the City required Qpost <= Qpre.

- Qpre for typologies: 20-25 L/s/Ha (no pre impervious), 150 L/s/Ha (post=pre impervious).
- Projects that meet 24 mm/day retention also achieve > **95% release rate reduction**. Tank achieves < 50%.

Study Observations

5. **Green roofs** are necessary to achieve targets when infiltration is constrained (see Task 5 Modeling results).

- For 24 mm/day retention: Part of solutions for Cat 1, most Cat 2. Not needed for Cat 3 (reduced setback).
- For 48 mm/day retention: Needed for most Cat 4.
- Modeling assumed dry soil before storm event. Saturated soil will decrease retention benefits.
- Nevertheless, despite Vancouver's peak evapotranspiration (summer) and rainfall (winter), **green roof likely to meet <u>annual</u> 70% retention**.

6. Impact in building construction **capital costs**:

- Infiltration not feasible, or setbacks/ parkades not reduced: 1-3% increase (24 mm/day).
- Infiltration feasible, and setbacks/ parkades are reduced: <1% (24 mm), <2% (48 mm/day).

7. Modelling results and other North American jurisdictional practices suggest that **greater levels of retention can be achieved** on CoV sites.

- The historic emphasis on **detention tanks** in many circumstances is likely due to familiarity and perceived/ real affordability, not feasibility.

Study Recommendations

Step 1 Sample Recommendations

- Advance Healthy Waters Plan.
- Evaluate current retention standards for achieving defined benefits to downstream drainage system and receiving waters.
- Evaluate costs and benefits of changing regulations.
- Recommend design standards that further support overarching citywide water quality goals.

Step 2 Sample Recommendations

Based upon Step 1 findings, potentially:

- Develop performance-based design standard.
- Evaluate and potentially modify parkade and setback requirements.
- Align green roof inspection.
- Design manual and technical resources to assist standardized submittals.
- Standardize submittal review process.
- Develop simple, alternative compliance hierarchy.