Landscape Carbon Benchmarking Study

Toronto

dtah

This report was prepared by DTAH to inform the development of future policy related to carbon performance in landscape design. It responds to specific instructions and objectives defined by our client. The findings, analysis, and recommendations are based on data and assumptions considered reliable at the time of writing.

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Executive Summary

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Executive Summary

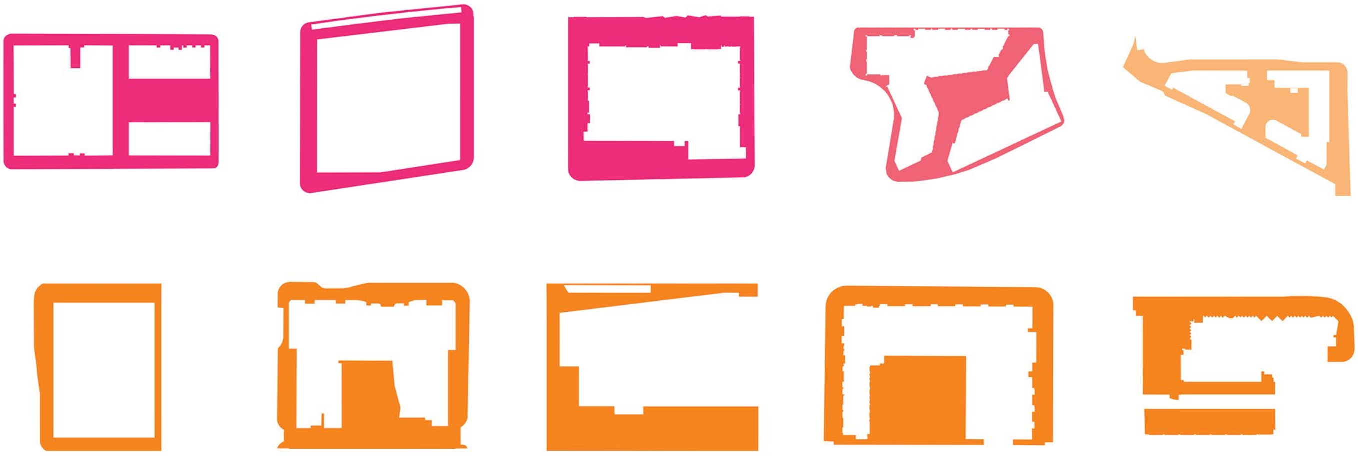
Context

Cities across Canada are increasingly adopting ambitious net-zero carbon targets. A critical aspect of achieving these goals is addressing embodied carbon - the greenhouse gas emissions from the production, transportation, and construction of materials used in urban development. While much attention has focused on buildings, landscapes also contribute substantially to a project's total carbon footprint. Yet, there are few established benchmarks or guidelines for assessing and managing embodied carbon in urban landscapes.

This study provides initial benchmarks for embodied carbon intensity by evaluating a representative sample of landscape projects in Toronto. While focused on Toronto-based sites, its insights and recommendations are broadly applicable to municipalities seeking to embed carbon-conscious practices in urban development.

Methodology

The study assessed 10 representative urban development sites using Pathfinder, an online landscape carbon accounting tool. The analysis calculated upfront carbon emissions - emissions from material sourcing, manufacturing, transportation, and installation - as well as potential carbon sequestration by plants over a standard 60-year period. Sites were selected to reflect typical urban development landscapes, including a range of open spaces, residential frontages, streetscapes, circulation areas, and courtyards.



Key Takeaways

- **Carbon Intensity Range:** Net carbon intensities across studied development sites range from 225 to 388 $kgCO_2e/m^2$.
- **Major Carbon Contributors:** Using the predefined material categories in Pathfinder, Concrete Hardscape, Soil Amendments, and Aggregate Asphalt Hardscape are the top three carbon contributors, collectively accounting for approximately 85% of a typical project's carbon footprint.
- **Softscape's Role in Carbon Reduction:** In dense urban settings, limited space and infrastructure demands constrain meaningful carbon sequestration through planting. While vegetation alone cannot offset embodied carbon at scale, expanding softscape lowers carbon intensity by displacing high-impact hardscape materials like concrete and asphalt assemblies. Designed with ample soils and resilient species, it also delivers essential co-benefits—cooling, stormwater management, and biodiversity.
- **Design Adaptations Matter:** A low-carbon redesign of a case study project demonstrated a >30% reduction in carbon intensity, highlighting the potential for immediate improvements through material selection and design strategies.

Conclusions & Recommendations

The study's recommendations are grouped into two categories, offering practical strategies for reducing embodied carbon in landscape design, as well as broader guidance for municipalities to support effective policy development and implementation:

1. Design Strategies to Reduce Embodied Carbon

Landscape architects and designers can significantly lower embodied carbon by incorporating carbon considerations early in their design process. Prioritizing lightweight materials and construction methods, increasing vegetation cover, reducing unnecessary hardscape, and sourcing materials locally or from reclaimed sources are all effective strategies. Thoughtful, low-carbon material and assembly choices offer immediate and practical opportunities to substantially reduce a project's embodied carbon footprint:

2. Policy and Implementation Strategies for Municipalities

Municipalities have an important role to play by embedding embodied carbon accounting into development approval processes. Establishing clear and defensible carbon-intensity targets based on benchmarks, standardizing reporting methods, and providing accessible guidance and resources will streamline implementation and encourage broader adoption. Supporting innovation through partnerships, sharing best practices, and building internal staff expertise will further accelerate the transition toward lower-carbon urban landscapes.

Glossary of Terms

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Glossary of Terms

Carbon Dioxide Equivalent (CO_2e):

The carbon dioxide equivalent (CO_2e) is a way to calculate GHG emissions by multiplying the amount of gas by its Global Warming Potential (GWP) (See definition below). This allows materials, such as concrete, to be measured equally on a per-unit basis to determine environmental impact. (CLF)

Carbon Footprint:

The total amount of greenhouse gas emissions, primarily carbon dioxide, released directly or indirectly throughout a landscape's life cycle. (One Click LCA)

Carbon Intensity:

The amount of carbon dioxide equivalent (CO_2e) emissions per unit of area or activity. In the context of landscape architecture, Carbon Intensity is quantified in kilograms of CO_2e per square meter ($kgCO_2e/m^2$), providing a metric for assessing the carbon impact of materials, details and assemblies.

Carbon Sequestration:

The active storing of carbon from the atmosphere into vegetation or soils. (Carbon Conscience)

Circulation (Landscape Category):

In the context of this study, this landscape category includes laneways, driveways and pedestrian mid-block connections. It excludes any pathways within POPS and Courtyards. Circulation is entirely on private property.

Climate Positive Design:

Design that reduces emissions and increases sequestration over a project's life span while also providing environmental, cultural, and economic co-benefits such as biodiversity, equity, and resilience. (ASLA CAP)

Development Site:

In this study, a development site refers to the entire area within the property boundary, including both built structures and landscape elements.

Embodied Carbon:

Estimate of the probable carbon emissions from a material or product's sourcing, fabrication, transport, and installation on site. (Carbon Conscience)

Environmental Product Declaration (EPD):

An EPD transparently reports objective, comparable, and third-party verified data about products and services' environmental performances from a lifecycle perspective. (EPD International) Typically these documents capture emissions from raw material extraction through manufacturing. They don't include transportation to a construction site or emissions associated with installation. (CLF)

Frontages (Landscape Category):

In the context of this study, frontages are defined as the spaces between building entrances (whether for non-residential at-grade uses or shared residential lobbies) and the street sidewalk or property line. These areas are designed to facilitate seamless access between public and private realms by minimizing obstacles and, in some cases, blurring the boundaries between them.

Global Warming Potential (GWP):

"A measure of how much energy the emission of 1 ton of a gas will absorb over a given period of time, relative to the emission of 1 ton of carbon dioxide (CO_2). The larger the GWP, the more that a given gas warms the Earth compared to CO_2 over that time period. The time period usually used for GWPs is 100 years. GWPs provide a common unit of measure, which allows analysts to add up emissions estimates of different gasses (e.g., to compile a national GHG inventory), and allows policymakers to compare emissions reduction opportunities across sectors and gasses." (EPA)

Greenhouse Gases (GHG):

Any gas in the atmosphere emitted by human activity that absorbs and re-emits heat. There are seven GHGs covered by Kyoto Protocol: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), Sulphur hexafluoride (SF_6), and Nitrogen trifluoride (NF_3). (One Click LCA)

kgCO_2e (kilograms of carbon dioxide equivalent):

A standard unit for measuring the impact of greenhouse gas emissions. It expresses the total climate effect of various gases (such as carbon dioxide, methane, and nitrous oxide) in terms of the amount of CO_2 that would cause the same global warming. This standardization is based on each gas's global warming potential (GWP), which compares the heat trapped by a specific gas to that of CO_2 over a set period, typically 100 years. (Terrascope)

Life Cycle Assessment (LCA):

A comprehensive methodology used to evaluate the environmental impact of a building from cradle to grave, considering all stages of its life cycle, including materials, construction, operation, maintenance, renovation, and disposal. (One Click LCA)

Open Space (Landscape Category):

In the context of this study, the Open Space category includes Privately Owned Publicly Accessible Spaces (POPS) and Courtyards.

Operational Carbon:

In contrast to embodied carbon, operational carbon refers to the greenhouse gas emissions from energy consumption from activities like maintenance or repair. Associated with the life-cycle phase B (use stage). (CLF)

POPS:

Privately Owned Public Spaces - or POPS - are outdoor open spaces that are accessible to the public without any charge or barrier, but are privately owned and maintained.

Stoops (Landscape Category):

In the context of this study, residential stoops are the small "yards" that front grade-related units. They are situated between the sidewalk/property line and the building face and lead to the private front door and often include a small front patio space. Stoops are often classified as "private amenity space" in the development approvals process.

Streetscape (Landscape Category):

In the context of this study, Streetscapes refer to the boulevard areas within the public right-of-way (ROW) extending from the back of the curb to the property line. These spaces are frequently rebuilt in coordination with new developments. The design of this zone is primarily dictated by established City standards.

Tonnes CO_2e (metric tonnes of carbon-dioxide equivalent):

A standardized unit for reporting greenhouse-gas emissions at larger ("macro") scales. One tonne CO_2e equals 1,000 kg CO_2e and represents the combined climate-warming impact of multiple gases – carbon dioxide, methane, nitrous oxide, etc. – expressed as the amount of CO_2 that would create the same warming over a 100-year period. Because it aggregates emissions in a single, easily comparable figure, tonnes CO_2e is the common metric used in corporate inventories, national greenhouse-gas reporting, carbon markets, and net-zero targets.

Introduction

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Context

Reducing embodied carbon is increasingly recognized as critical for achieving ambitious municipal climate targets. In Canada, new construction contributes significantly to total emissions, making embodied carbon reduction a priority for policy and design practices in urban development.

Municipalities have begun integrating embodied carbon considerations into public projects through targeted requirements and carbon performance benchmarks, often using tools like Pathfinder to evaluate landscape emissions. Extending similar standards to private-sector developments represents the next essential step toward meeting emerging municipal net-zero objectives. Establishing clear and achievable carbon benchmarks for landscape construction can help municipalities and industry align, promoting consistency and accountability in driving down emissions.

Purpose

This study analyzes ten urban development sites representing common private development landscape types in Toronto, using Pathfinder - a free online tool for landscape architects - to calculate each site's upfront carbon emissions and estimated sequestration capacity. The goal is to establish a baseline understanding of embodied carbon in contemporary urban landscape design and identify opportunities to reduce emissions through material selection and design strategies.

The selected projects reflect typical development practices during a time when carbon impacts were not yet a formal consideration in design standards. The study does not evaluate individual project performance, but instead provides an objective snapshot of current conditions, offering a foundation for future guidelines, benchmarks, and policies to support low-carbon landscape design across the development industry.

Methodology

This section outlines the methodology used to generate the study's results. It provides a clear description of the key inputs and assumptions to ensure the analyses can be accurately replicated and refined over time.

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4.1 Approach

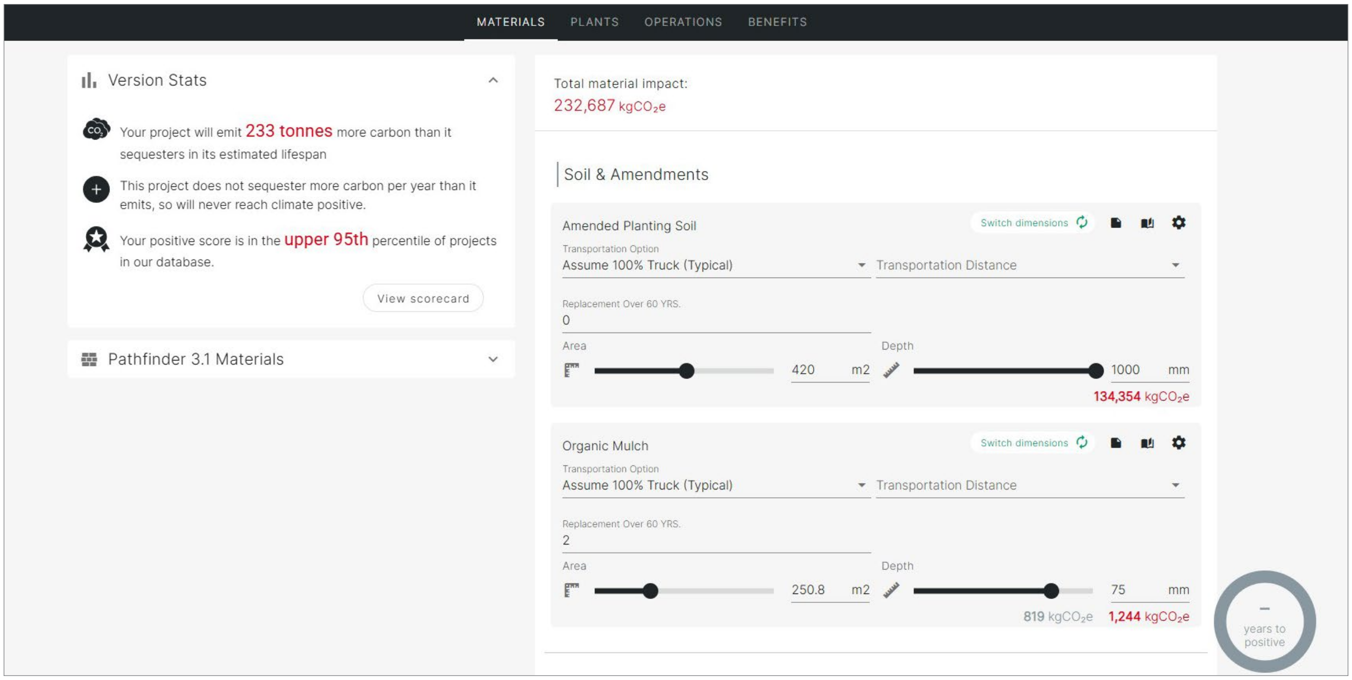
The free online tool “Pathfinder 3.0” (app.climatepositivedesign.com) created by *Climate Positive Design* was used to generate the results in this study.

To achieve the highest level of detail, each project was divided into distinct areas based on landscape categories and types. For example, a project with four landscape categories was entered into Pathfinder as four separate “sub-projects” in this study.

To conduct the analysis, the study team used Site Plan Application (SPA) drawing sets obtained from the City of Toronto’s publicly accessible online development application portal. Two projects – HR3 and MR3 – used Issued for Construction (IFC) drawings. All drawings were in PDF format.

Quantity take-offs were generated by scaling drawing PDFs in Bluebeam Revu (Versions 8.5.1 & 21.3) and then manually input into the Pathfinder tool for analysis. Since drawing sets were produced by various landscape professionals, their clarity and completeness varied. To ensure consistency across all projects, general technical assumptions were applied (see Appendix A: Technical Assumptions).

The global warming potential presets in Pathfinder were used for each available material type. When specific materials were not available on Pathfinder, Environmental Product Declaration (EPDs) were sourced from the Internet or via sales representatives and then input into Pathfinder as custom materials. These custom materials were then used across projects, where appropriate.



Your project will emit 233 tonnes more carbon than it sequesters in its estimated lifespan

This project does not sequester more carbon per year than it emits, so will never reach climate positive.

Your positive score is in the upper 95th percentile of projects in our database.

Total material impact:
232,687 $kgCO_2e$

Soil & Amendments

Amended Planting Soil
Transportation Option: Assume 100% Truck (Typical)
Transportation Distance
Replacement Over 60 YRS.: 0
Area: 420 m2
Depth: 1000 mm
134,354 $kgCO_2e$

Organic Mulch
Transportation Option: Assume 100% Truck (Typical)
Transportation Distance
Replacement Over 60 YRS.: 2
Area: 250.8 m2
Depth: 75 mm
819 $kgCO_2e$ 1,244 $kgCO_2e$

Pathfinder’s online interface

4.2 General Assumptions

The following general assumptions have been made regarding inputs and outputs in Pathfinder:

- **Existing Site Conditions Not Considered:** This analysis focuses solely on proposed site conditions. While development projects typically alter existing landscapes—such as demolishing structures or removing mature trees, which contribute to carbon impacts—these factors were not included in the assessment.

- **At-Grade Features Only:** This study considers only at-grade landscape features. Amenity terraces, green roofs, and other rooftop or elevated outdoor amenities were excluded from the assessment.

- **Depth of Assessment:** In stratified conditions, below-ground assessment of landscape assemblies and materials have been made from the top of the roof assembly to the finished surface. In non-stratified conditions, the assessment was completed from the top of the compacted or undisturbed subgrade to the finished surface (finished grade). In both stratified and non-stratified conditions, furnishings and other materials above the finished surface have also been included.

- **No Utilities:** The study did not analyze the impact of any above or below grade utilities.

- **Co-Benefits:** No co-benefits such as biodiversity or water use have been analyzed as part of this study, even though Pathfinder does allow for the high-level assessment of these. The study focuses on upfront carbon impacts only.

- **Limited Carbon Stages:** This study (and Pathfinder) focuses on Stage A and some Stage B carbon emissions (see section 4.3)

A detailed list of general technical assumptions applicable to all projects is provided in Appendix A: Technical Assumptions for reference.

4.3 Life Cycle Stages Assumptions

This study's assumptions relative to the life cycle stages (Figure 1) are defined within the Pathfinder tool. The following sections highlight the key assumptions listed by Climate Positive Design, the tool's creators. For additional information on assumptions integrated into the Pathfinder tool, refer to:

Climate Positive Design (2024). Pathfinder 3.0: Methodology and Data Sources. Accessed online on January 19, 2025: https://climatepositivedesign.com/education/methodology-report/

Impact Category

The impact category for Pathfinder is Global Warming Potential (GWP) measured in kilograms of carbon dioxide equivalent (kgCO2e), meaning it is inclusive of other greenhouse gas impacts beyond carbon dioxide (CO2).

Reference Study Period (RSP)

The RSP, or life of the "project" is defined as 60 years.

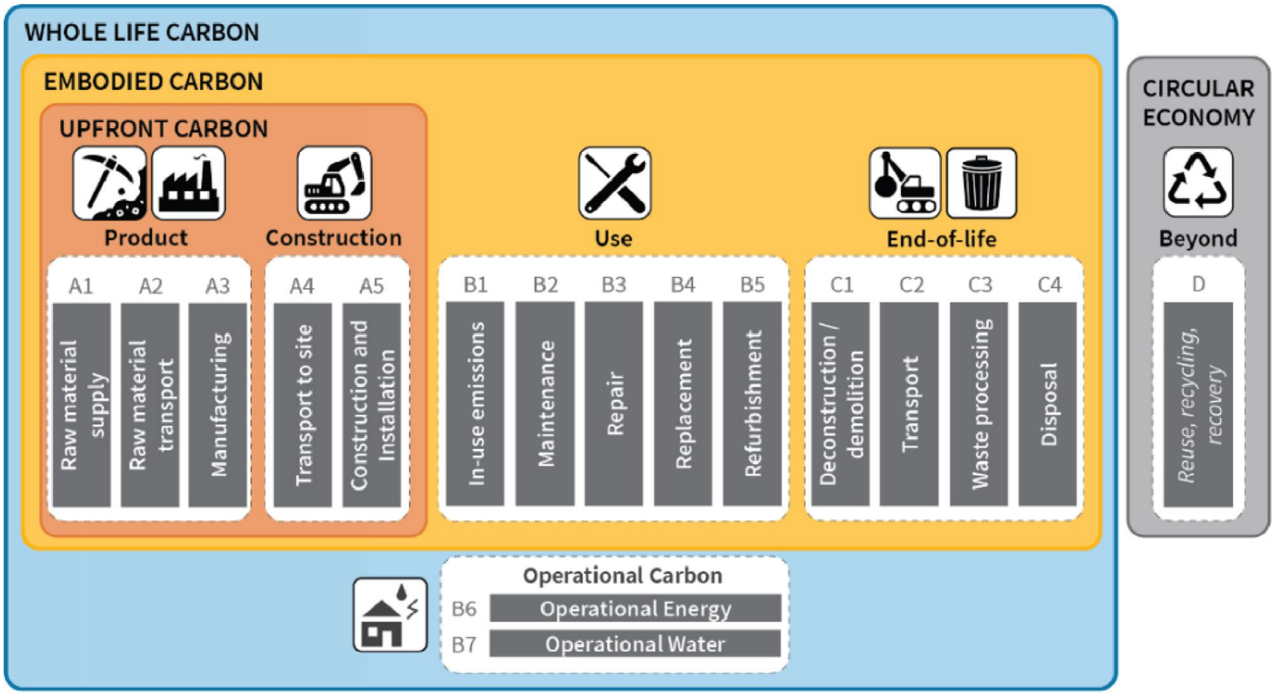


Figure 1: Life cycle stages and modules used in LCAs. (Source: Carbon Leadership Forum, 2024).

Included Stages

Pathfinder includes the life cycle stages and modules listed on the right. Stages in green text are included in Pathfinder, whereas stages in pink text are not included. This information was drawn from Pathfinder's "Methodology and Data Sources Report", version 3.0 at the time of study publication.

It is important to understand which life cycle stages are included and excluded in Pathfinder, as this has a direct impact on the results. Other life cycle assessment tools or methodologies may define their system boundaries differently—such as including end-of-life emissions or broader operational impacts—which can lead to variations in carbon intensity outcomes. For the purposes of this study, all calculations were completed using Pathfinder, and the results should be interpreted within the scope and assumptions of that tool.

Product Stage:
- A1: Raw Material Supply
- A2: Transport
- A3: Manufacturing

Construction Stage:
- A4: Transport, via user-supplied multiplier for transport type and distance
- A5: Construction Process Stage, including:
- Site Development
- Deconstruction of Pre-Existing Construction Works (including demolition and removal of hardscape, existing trees and ecosystems)
- Installation Processes, via a contingency of 2.5% of the emissions of materials and planting to be installed.

Use Stage:
- B1: Use is not included.
- B2: Maintenance emissions are included as fertilizer and turf emissions due to mowing, fertilizer, and irrigation application.
- B3: Repair is not included.
- B4: Replacement of materials during the lifespan of the project, using informed assumptions or per user-entered multiplier
- B5: Refurbishment is not included.
- B6: Operational energy for planting maintenance equipment
- B7: Operations Water Use includes water for irrigation and other outdoor water uses.
- B8: Users' Activities are not included.

End of Life Stage:
- C1-C4: End of Life phases are not included, as this is considered beyond the scope of the design team.

Beyond building life cycle:
- D: Benefits and Loads Beyond the System Boundary**:** Biogenic sequestration and carbon storage are not currently included within ISO 1040, EN15978, ASTM E2921 and ISO 21932. Pathfinder, aligned with Carbon Conscience, includes biogenic sequestration and carbon storage within Circular Economy Stage D.

4.4 Selected Case Studies

This study analyzed ten (10) case studies (see Table 1), selected to represent a diverse range of development projects across Toronto (Figure 2) spanning contexts from constrained urban core sites to more expansive locations in surrounding districts. The sample includes a variety of built form types (high-, mid-, and low-rise), land uses (mixed-use, office, residential, educational), budget ranges, and landscape architects.

Table 1: List of Ten Selected Case Studies

High-Rise	Mid-Rise and High-Rise	Mid-Rise	Low-Rise and Mid-Rise
HR1	MR+HR1	MR1	LR+MR1
HR2		MR2	
HR3		MR3	
		MR4	
		MR5	

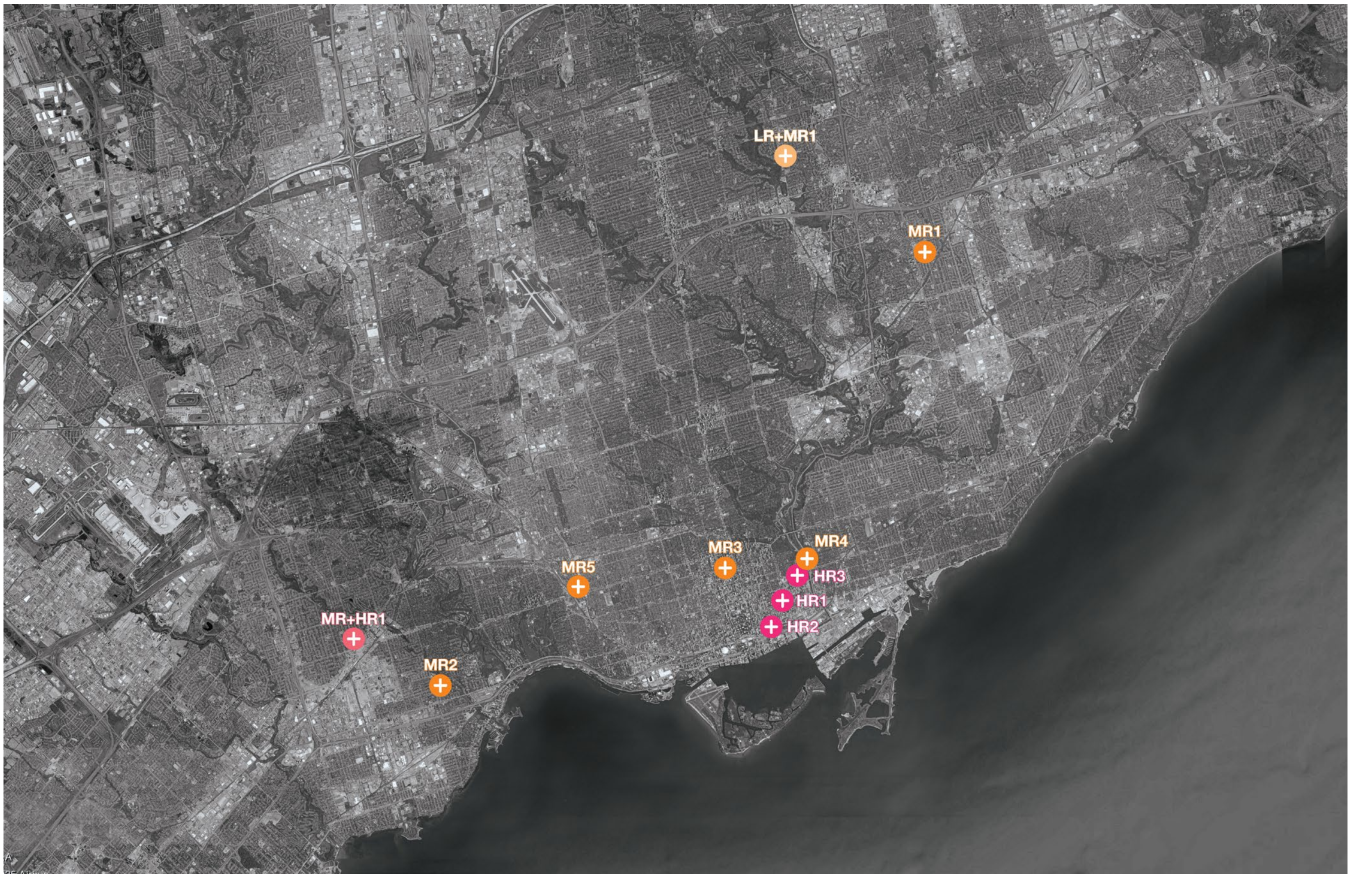
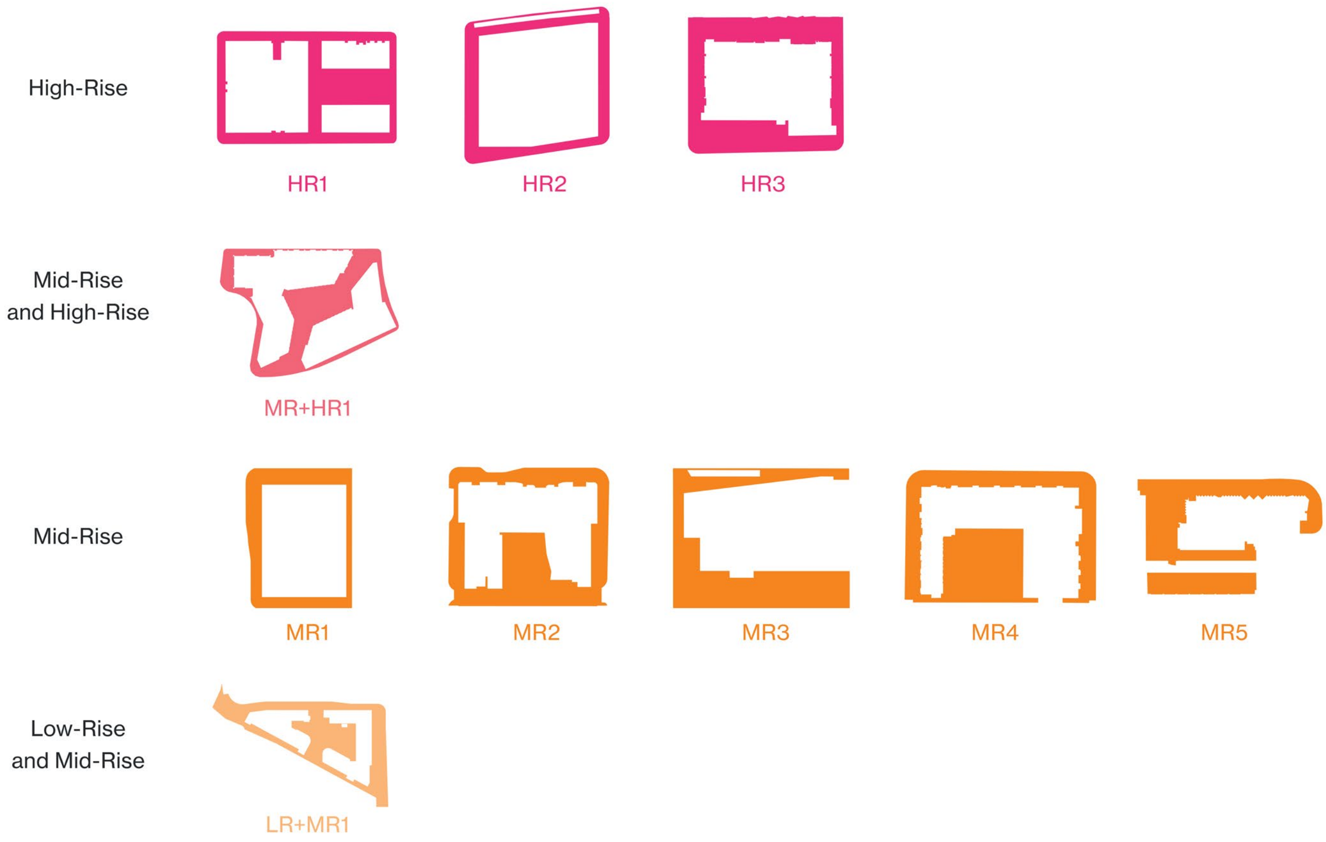


Figure 2: Distribution of Case Study Projects within the City of Toronto

Plan Icons of Case Studies*



** not to scale*

4.5 Project Specific Assumptions

Each project has a unique landscape design, novel details, and project specific construction methods, which cannot always be fully captured using Pathfinder's preset materials and product library. To enhance the replicability of this study, Appendix A: Technical Assumptions outlines the project-specific assumptions made during the analysis.

4.6 Landscape Categories

To effectively analyze and compare landscapes across multiple projects, it is necessary to segment different landscape areas into distinct groupings. This approach allows for a more structured and consistent evaluation, ensuring that similar spaces can be assessed based on shared characteristics and functions. Categorization also enables a more granular level of detail in the analysis, helping to identify patterns and areas for improvement.

Each selected case study typically includes multiple landscape categories. Across the case studies, nearly ten distinct landscape categories have been identified. For simplicity, these have been grouped into the following five categories: Open Space, Stoops, Frontages, Circulation, and Streetscape. These categories provide a clear framework for understanding the function and role of each distinct landscape area within different projects, supporting a more systematic and comparable analysis.

Table 2: Summary of Landscape Categories within the Case Studies

Project Name	Open Space	Stoop	Frontage	Circulation	Streetscape
HR1	Yes (POPS)	Yes	Yes	Yes (Laneway)	Yes
HR2	-	-	Yes	-	Yes
HR3	Yes (POPS)	Yes	Yes	Yes (Laneway)	Yes
MR+HR1	Yes (Courtyard)	Yes	Yes	-	-
MR1	-	-	Yes	-	Yes
MR2	Yes (Courtyard)	Yes	Yes	Yes (Laneway)	Yes
MR3	Yes (Courtyard)	-	Yes	Yes (Mid-Block)	Yes
MR4	Yes (Courtyard)	Yes	Yes	-	Yes
MR5	Yes (Courtyard + POPS)	-	Yes	Yes (Laneway)	Yes
LR+M1	Yes (Courtyard)	-	Yes	Yes (Laneway + Mid-Block)	Yes

Open Space

The Open Space category includes Privately Owned Publicly Accessible Spaces (POPS) and Courtyards.

- POPS are secured by easement during the development approvals process and are accessible to anyone without charge or barrier. They are typically passive spaces that feature hardscapes, seating, pedestrian lighting, furnishings, trees and planting. POPS come in many forms, but in the case studies analyzed for this study, they primarily took the form of plazas and forecourts.
- Courtyards are private spaces designed primarily for residents or building tenants, such as office workers. While they share some characteristics with POPS, courtyards are typically located behind buildings, further from the public street, and may be gated to restrict access. They often include a broader range of features such as active elements like play structures or passive features like gardens or dining areas. In the development approvals process, courtyards are generally classified as private amenity space.

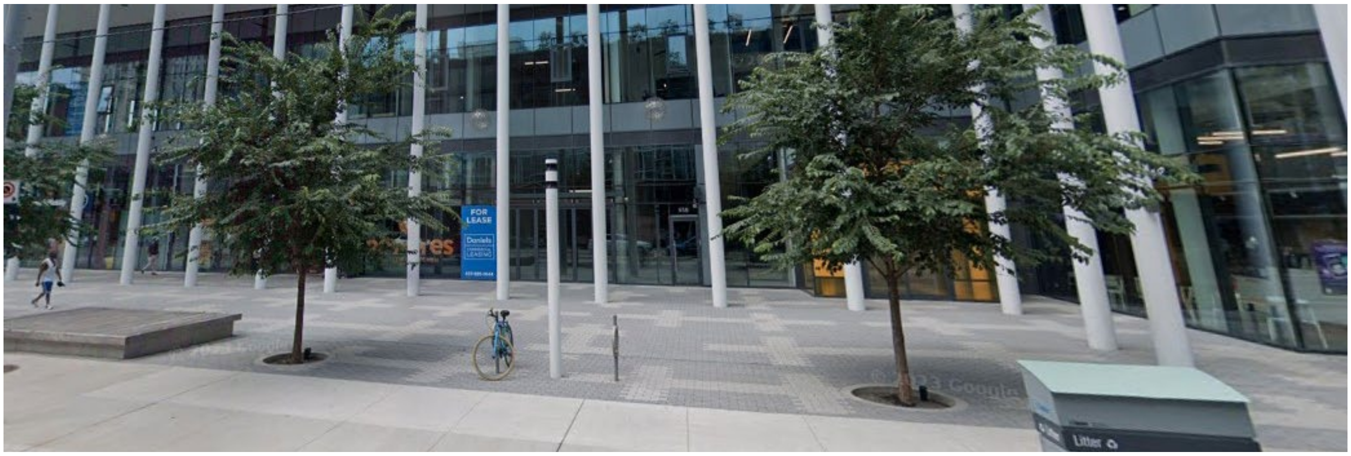


Figure 3: Example of an Open Space (POPS) at HR3

Figure 4: Example of an Open Space (Courtyard), at MR+HR1

Circulation

This landscape category includes laneways, driveways, pick-up/drop-off areas, and pedestrian mid-block connections. It excludes any pathways within POPS and Courtyards. Circulation is entirely on private property.

Stoops

Residential stoops are small front-yard spaces associated with grade-related residential units. While located on private property, they typically face the public street and serve as an entryway to the unit's private front door. Stoops often include a small front patio and are generally classified as private amenity space in the development approvals process.

Figure 5: Example of a Circulation feature (Laneway), at HR3

Figure 6: Example of a Stoop, at MR4

Frontages

Frontages are the spaces between building entrance areas and the street sidewalk or property line. Frontages provide clear and direct access to residential and non-residential entrances of a building. They are typically at-grade to ensure easy accessibility. Designed to facilitate seamless access between the public and private realms, frontages aim to minimize obstacles and, in some cases, blur the boundaries between them.

Streetscape

In this study, Streetscape refers to the areas within the public right-of-way (ROW) extending from the back of the curb to the property line. These spaces are frequently rebuilt in coordination with new developments. The design of this zone is primarily dictated by established municipal standards. No below or above grade utilities were included in the analysis.

Figure 7: Example of a Frontage, at MR2

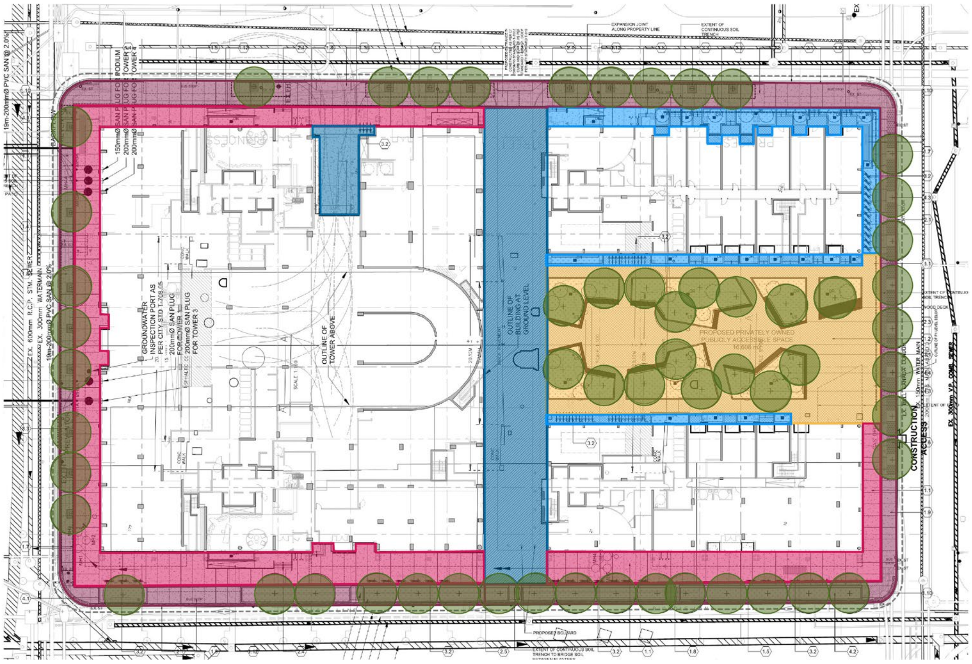
4.7 Case Study Site Plans & Landscape Categories

The following pages show each site in larger format, with landscape categories color-coded consistently across all projects. This allows for easy visual comparison of how each category is distributed on each site.

While these drawings are not to scale and have been resized to fit the page, the total landscape area (including both private landscape and streetscape) is noted for each site to support comparison.

HR1

Landscape Area: $5{,}792\text{m}^2$

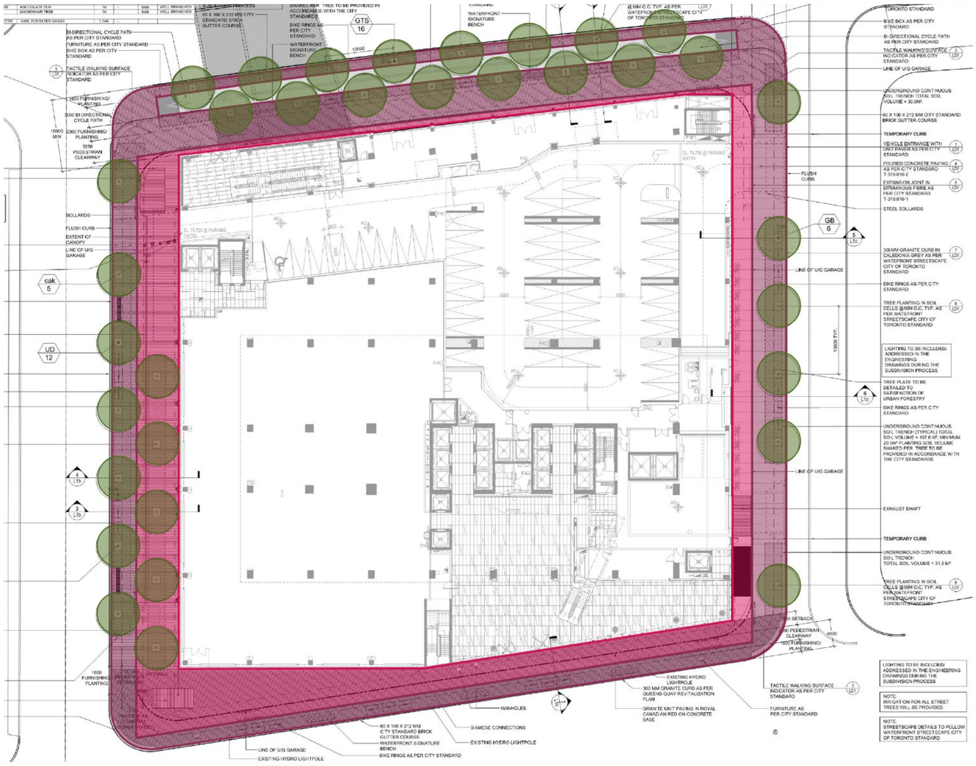


🟪 Streetscape
🟥 Frontages
🟨 Open Space
🟦 Stoops
🟦 Circulation

HR2

Landscape Area: 3,064m²

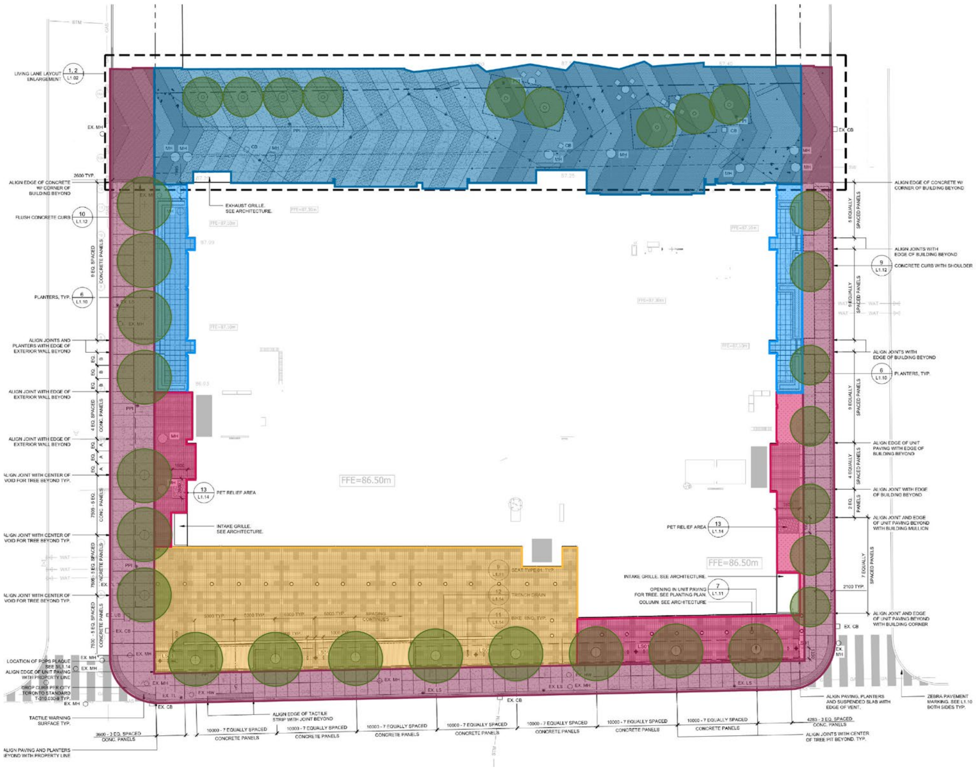
- 🟪 Streetscape
- 🟥 Frontages
- 🟧 Open Space
- 🟦 Stoops
- 🟦 Circulation



HR3

Landscape Area: 3,484m²

- 🟪 Streetscape
- 🟥 Frontages
- 🟧 Open Space
- 🟦 Stoops
- 🟦 Circulation



MR + HR

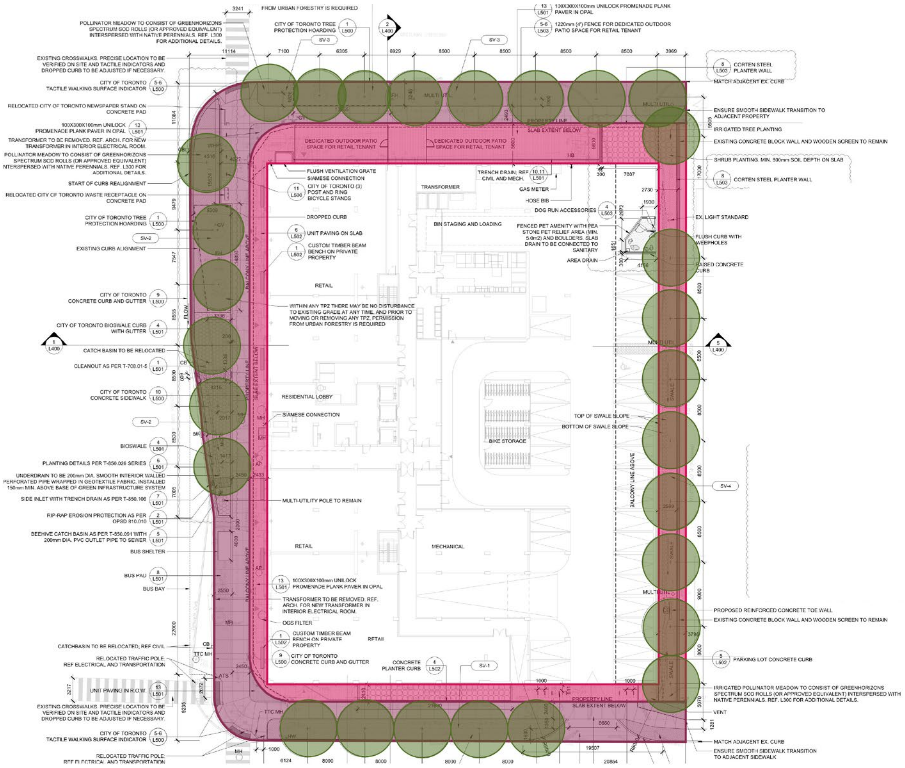
Landscape Area: 4,104m²

- 🟪 Streetscape
- 🟥 Frontages
- 🟨 Open Space
- 🟦 Stoops
- 🟦 Circulation

MR1

Landscape Area: 2,250m²

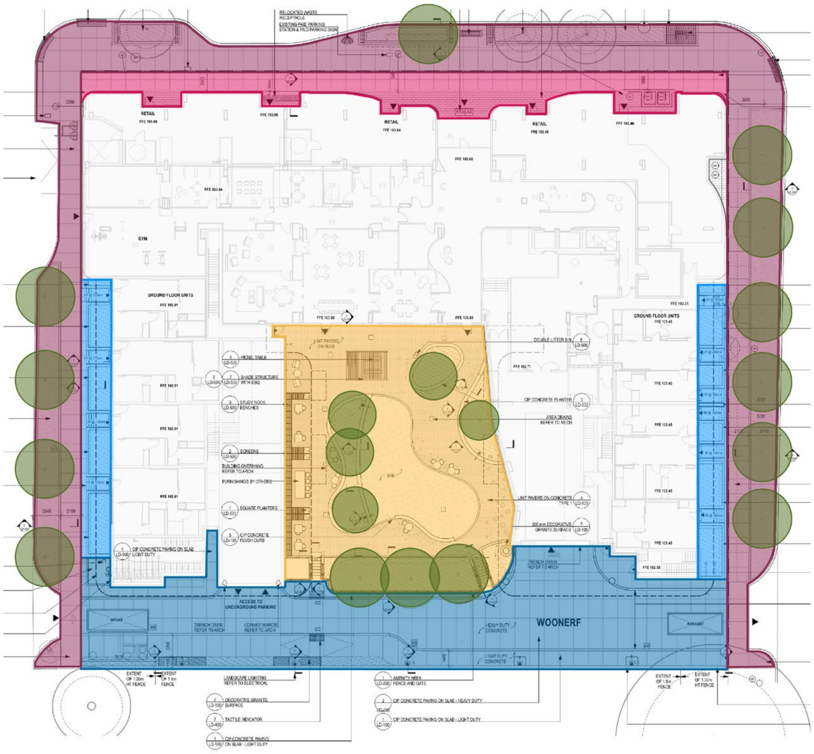
- 🟪 Streetscape
- 🟥 Frontages
- 🟨 Open Space
- 🟦 Stoops
- 🟦 Circulation



MR2

Landscape Area: 2,401m²

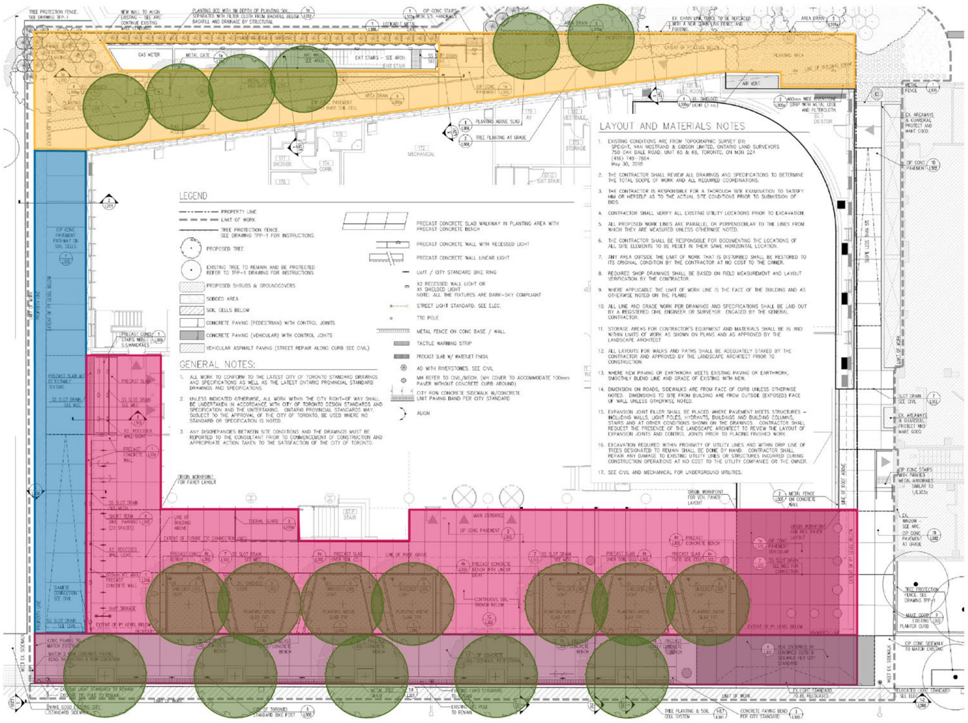
- 🟪 Streetscape
- 🟥 Frontages
- 🟧 Open Space
- 🟦 Stoops
- 🟦 Circulation



MR3

Landscape Area: 1,344m²

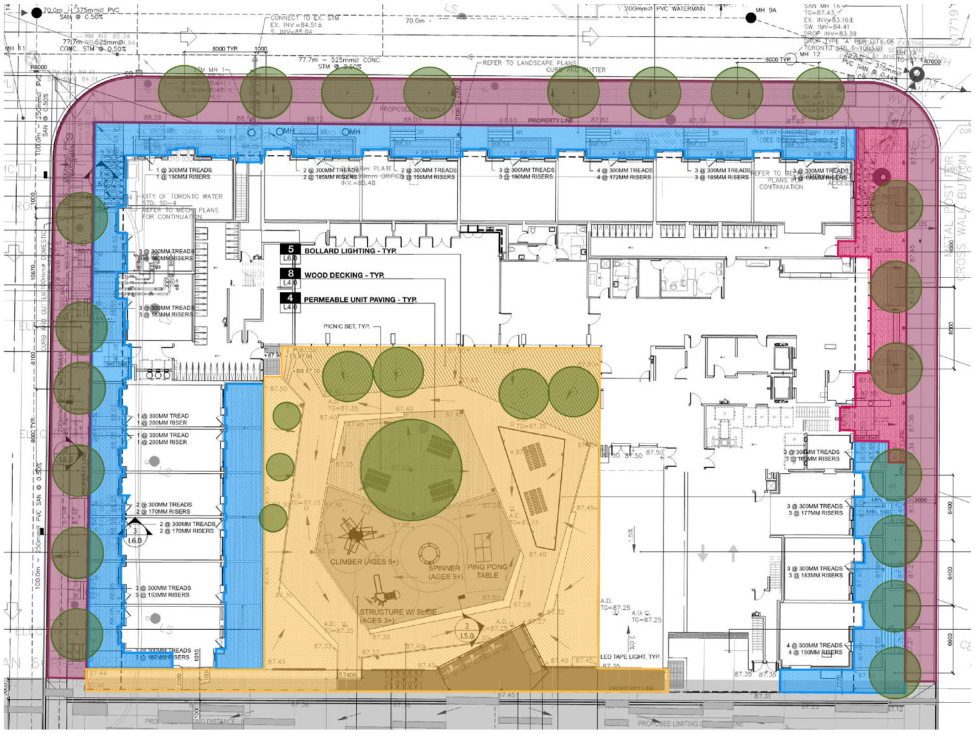
- 🟪 Streetscape
- 🟥 Frontages
- 🟧 Open Space
- 🟦 Stoops
- 🟦 Circulation



MR4

Landscape Area: 2,561m²

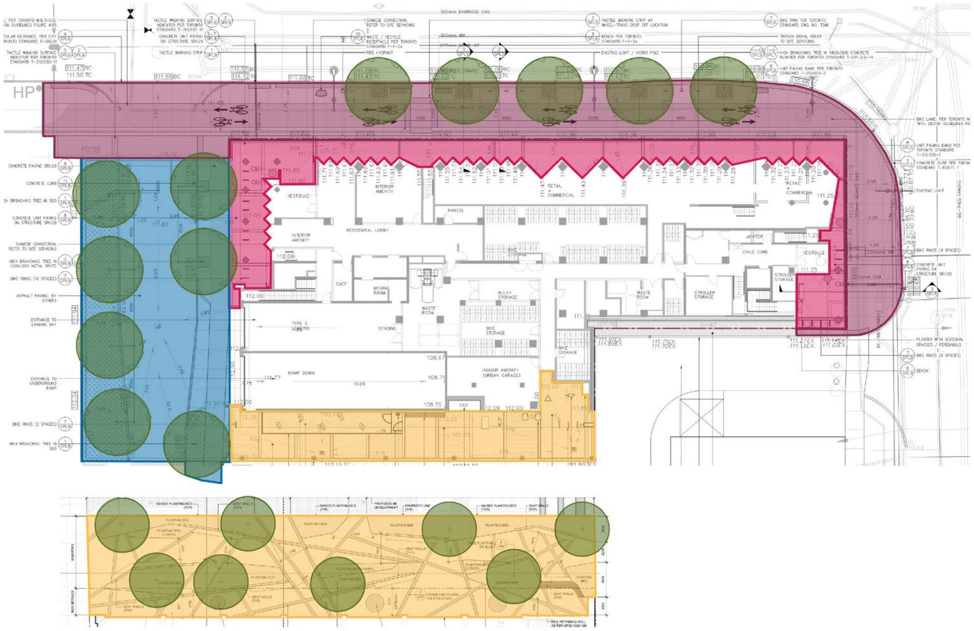
🟪 Streetscape
🟥 Frontages
🟧 Open Space
🟦 Stoops
🟦 Circulation



MR5

Landscape Area: 2,488m²

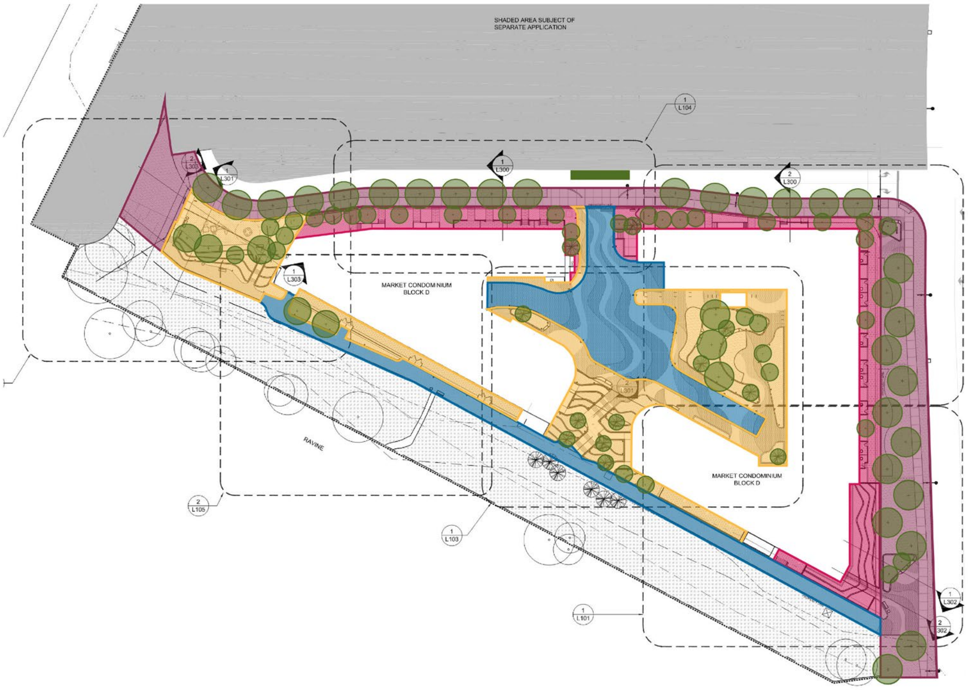
🟪 Streetscape
🟥 Frontages
🟧 Open Space
🟦 Stoops
🟦 Circulation



LR + MR1

Landscape Area: 7,363m²

🟪 Streetscape
🟥 Frontages
🟨 Open Space
🟦 Stoops
🟦 Circulation



4.8 Material Types

The material types analyzed in this study are drawn from Pathfinder’s predefined categories. For clarity, these materials have been grouped into two broad categories: Hardscape and Softscape (Table 3). While this distinction helps guide the Hardscape/Softscape Ratio analysis later in the report, it’s important to note that the boundary between the two can sometimes be difficult to define, particularly when considering subsurface elements. Examples of materials included within these types are also included.

Table 3: Material Types and Examples Used in this Study

Material Category	Material Type (Established by Pathfinder)	Material Examples
Hardscapes	Aggregate Asphalt Hardscape	• Asphalt Paving • Compacted Aggregate Base • Crushed Stone Paving (Decomposed Granite) • Pipe Bedding Material - Pea Gravel
	Brick Stone Hardscape	• Stone Paving or Pavers • Stone Steps
	Concrete Hardscape	• Cast-in-Place Concrete Mow Curb • Cast-in-Place Concrete Paving • Cast-in-Place Concrete Sonotube Footing • Cast-in-Place Concrete Spread Footing (Foundation) • Cast-in-Place Concrete Subslab • Cast-in-Place Concrete Wall • CMU Block Wall • Precast Concrete Pavement • Precast Concrete Stairs • Precast Concrete Unit Pavers • Precast Concrete Wall or Panels • Reinforcement for Concrete Mow Curb • Reinforcement for CIP Concrete • Reinforcement for CIP Concrete Paving • Reinforcement for CIP Sonotube • Reinforcement for Narrow CIP Concrete Walls • Reinforcement for Wide CIP Concrete Walls • Sand Setting Bed • Spread Footing • Welded Wire Mesh (Fabric) Reinforcement

Material Category	Material Type (Established by Pathfinder)	Material Examples
Hardscapes	Exterior Lighting	• Light Bollard • Light Pole Luminaire
	Furnishings	• Bike Ring • Bench • Chair • Bike Rack • Picnic Table • Pixel Seat • Table • Trash Receptacle • Seat (Metal)
	Metal Wood Hardscape	• Decking • Decking Fasteners • Expanded Metal Fencing • Metal Grates • Steel Fencing Fasteners (Lump Sum) • Steel Handrail • Tree Grates • Wood Fence
	Infrastructure Subsurface	• Area and Trench Drain Grate • Soil Cells • Geotextile Filter Fabric • Irrigation Mainline • Manhole Cover • Modular Suspended Pavement System • Perforated Drain Pipe • Trench Drain - CIP Concrete Body
	Site Elements	• ADA Truncated Dome Pavers • Steel Bollards (Custom) • Stone Boulders • Wood Pergola (Shade Structure)
	Planting Accessories	• Metal Edge Restraint
	Playground Athletic	• EPDM Safety Surface • Climber • Slide • Spinner • Safety Surface Pea Gravel • Synthetic Turf

Material Category	Material Type (Established by Pathfinder)	Material Examples
Softscapes	Soil Amendments	• Amended Import Soil • Organic Mulch
	Lawn	• Moderate Management Lawn
	Perennials and Perennial Grasses	• Perennials / Perennial Grasses
	Shrubs	• Deciduous Medium Shrub
	Trees	• Deciduous Medium Tree • Deciduous Large Tree

Results

The ten case studies produced a robust dataset, allowing for multiple avenues of analysis. This chapter presents the most relevant results aligned with the study's goals. The chapter also outlines the limitations of the results and offers considerations for their interpretation. Notably, all carbon intensities presented in this chapter are "net" values, calculated over a 60-year sequestration period.

5

5.1 Carbon Intensity Per Project

Carbon intensity is a useful metric for evaluating the overall impact of projects, as it enables meaningful comparisons of carbon footprints regardless of project size. It represents the amount of carbon emissions per unit of area (kgCO_2e/m²), allowing for standardized assessment across different developments. Figure 8 below illustrates the carbon intensity for each of the 10 case study sites. These results exclude the “Streetscape” category and focus solely on landscape elements within the property lines of each development. They are ranked from highest to lowest.

The results in Figure 8 show net carbon intensities ranging from **225 kgCO_2e/m² (MR1)** to **388 kgCO_2e/m² (HR2)**. **The overall average net carbon intensity for all projects is 274 kgCO_2e/m²**. Two out of three of the high-rise projects are the most intense of all projects. The low-rise and mid-rise project (LR+MR1) is the third least intense of all projects. This may be due to the high-rise sites being built out more densely within the property line, leaving minimal space for soft landscape. These sites are typically constructed entirely over structure, which limits opportunities for soil-based planting and reduces the overall potential for carbon sequestration and increases reliance on carbon-intensive hardscape materials.

The following sections will examine the design decisions that contributed to the range of carbon intensity results in greater detail.

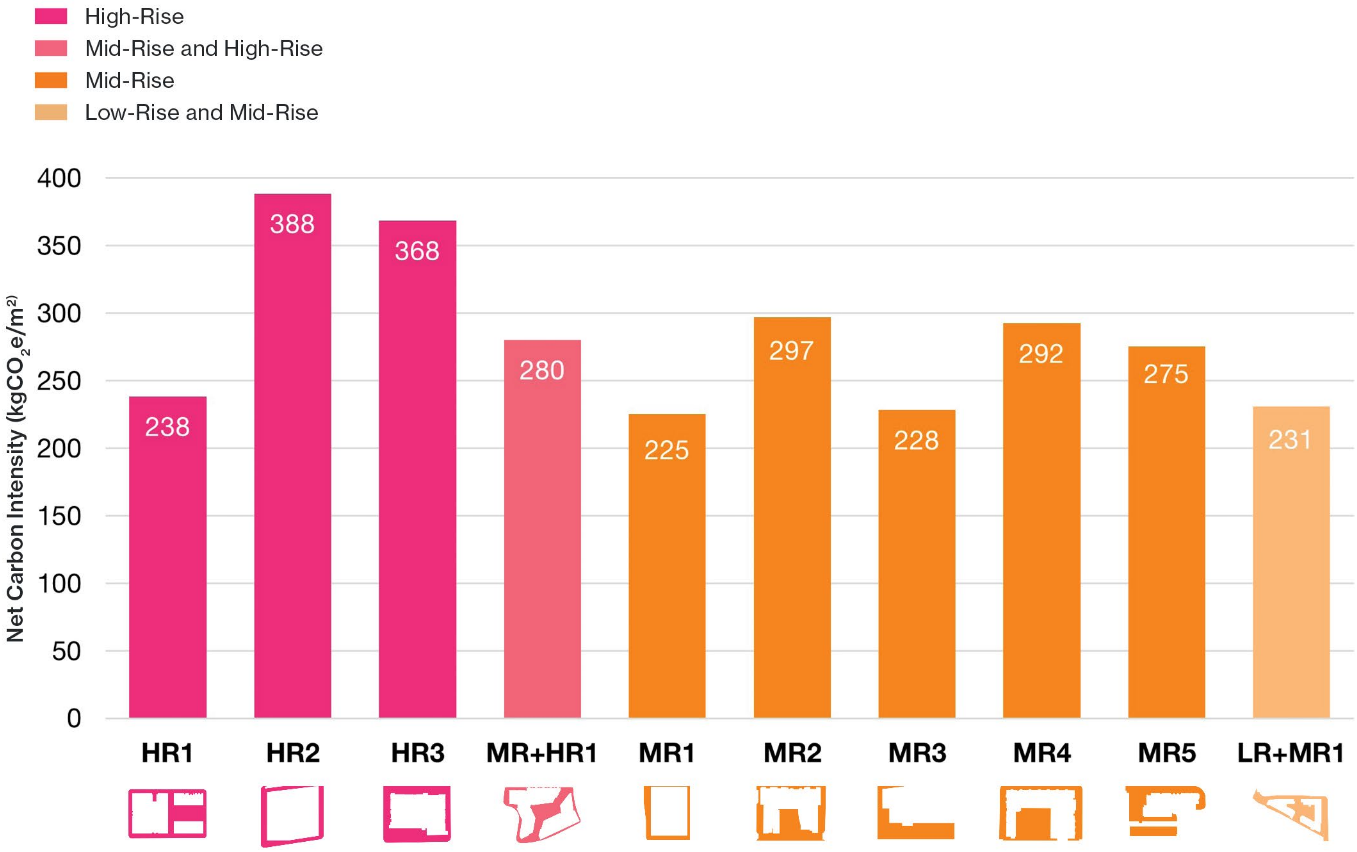


Figure 8: Net Carbon Intensity Per Project

5.2 Carbon Intensity Per Landscape Category

To further understand the impact of each project, it is useful to distinguish the carbon intensity per landscape category (Figure 9).

Carbon intensities in all categories range from 105 to 428 kgCO$_2$e/m^2

Figure 9 presents the net carbon intensity per landscape category, illustrating variation across different projects. The stacked bar chart breaks down carbon intensity into distinct landscape categories, highlighting a range from **105 kgCO$_2$e/m^2 (LR+MR1 Circulation)** to **428 kgCO$_2$e/m^2 (HR3 Circulation)**. This visualization demonstrates how different landscape types contribute to the overall carbon footprint of each project.

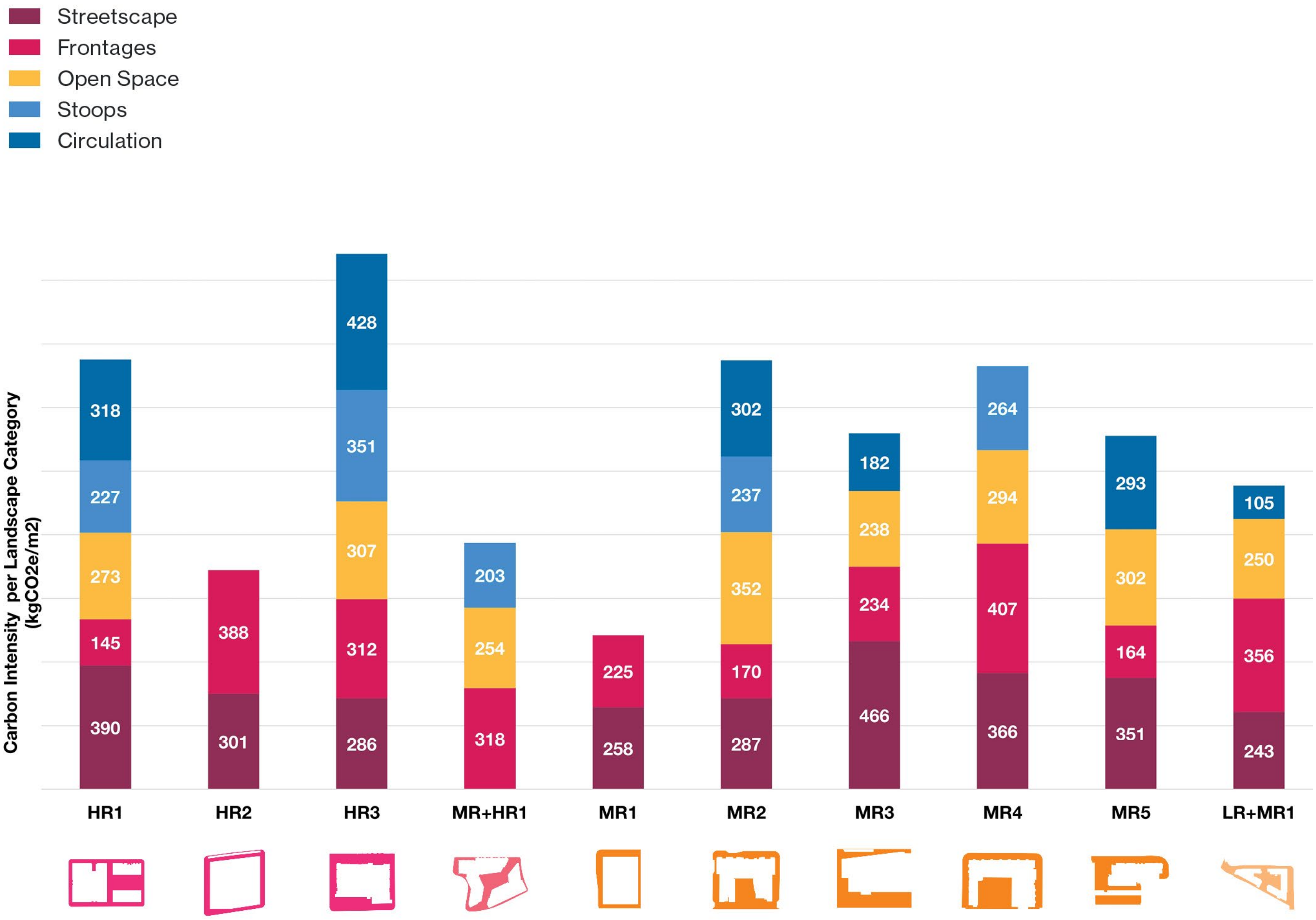


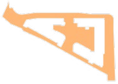
Figure 9: Net Carbon Intensity Per Landscape Category

Circulation

Six (6) out of ten (10) projects include a "Circulation" landscape, with carbon intensity ranging from **105 kgCO$_2$e/m^2 (LR+MR1)** to **428 kgCO$_2$e/m^2 (HR3)**. This represents the widest range among all landscape categories, reflecting the diversity of designs and functions within this category, which includes mid-block connections, driveways, and laneways. The average carbon intensity across all projects is **269 kgCO$_2$e/m^2**.

The least intensive design circulation landscape (LR+MR1) has both a laneway and a mid-block connection. The "Concrete Hardscape" (51%) and Aggregate & Asphalt Hardscape" (47%) material types constitute 98% of its carbon footprint. The laneway is mostly paved with precast concrete unit pavers and has no trees planted within the hardscape, limiting the need for soil cells and additional hardscape material. The mid-block connection is paved with stabilized aggregate paving, a material with a low-carbon footprint.

The most carbon-intensive design (HR3) is a "living lane" that integrates both servicing and placemaking features. This unique design requires a high number of concrete footings and manholes for stormwater tanks (not included in the analysis). While Concrete Hardscape (34%) and Aggregate & Asphalt Hardscape (24%) account for 58% of its total footprint, the remaining carbon impact is more evenly distributed across other material types.



Lowest:
LR + MR1
105 kgCO$_2$e/m^2

Figure 10: Project LR+MR1, the least carbon-intensive "Circulation"

Highest:
HR3
428 kgCO$_2$e/m^2

Figure 11: Project HR3, the most carbon-intensive "Circulation"

Stoops

Five (5) out of ten (10) projects include a “Stoops” landscape. Carbon intensities for stoops range from **203 kgCO$_2$e/m^2 (MR+HR1)** to **351 kgCO$_2$e/m^2 (HR3)**. The average carbon intensity across all projects is **247 kgCO$_2$e/m^2**.

The least intensive Stoop (MR+HR1) is at grade, has vegetated screening, and includes no built fences or gates. Unlike most stoops that face the public street, these are internally oriented around a courtyard. Its carbon footprint is primarily driven by Concrete Hardscape (46%) and Soil & Amendments (39%), which together account for over 85% of total emissions.

The most intensive design (HR3), on the other hand, includes a concrete wall assembly that separates the public and private realms and includes planting beds. Although this low wall is an interesting public realm feature, the type and weight of the material choices make this assembly carbon-intensive. “Concrete Hardscape” (55%) and “Aggregate & Asphalt (32%) Hardscape” material types constitute 87% of its carbon footprint.

Lowest:
MR + HR1
203 kgCO$_2$e/m^2

Figure 12: Project MR+HR1, the least carbon-intensive “Stoop”

Highest:
HR3
351 kgCO$_2$e/m^2

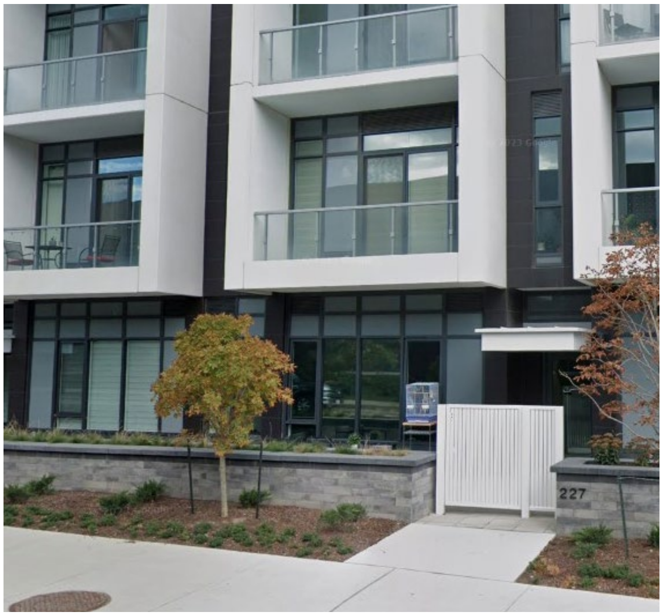


Figure 13: Project HR3, the most carbon-intensive “Stoops”

Open Spaces

Eight (8) out of ten (10) projects include a “Open Space” landscape (POPS and courtyards). Carbon intensities range from **238 kgCO$_2$e/m^2 (MR3)** to **352 kgCO$_2$e/m^2(MR2)**. The average carbon intensity across all projects is **276 kgCO$_2$e/m^2**.

The least carbon-intensive Open Space (MR3) is a courtyard located on top of a below-grade parking structure. Unlike other designs, this “park-like” courtyard features a high proportion of softscape with minimal hardscape and fixed elements (such as garden structures, screens, raised planters, or CIP concrete features such as walls or curbs), contributing to its lower carbon intensity. “Soil & Amendments” (73%) and “Concrete Hardscape” (18%) material types constitute nearly 92% of its carbon footprint.

The most intensive Open Space (MR2) is a courtyard located on top of a below-grade parking structure. Serving as an amenity space for residents, it has many fixed elements for its relatively small size compared to other designs, including pergolas, screens, raised planters, curbs and walls. Fixed elements in this courtyard include “Soil & Amendments” (39%) and “Concrete Hardscape” (32%) material types constitute 71% of its carbon footprint, suggesting its carbon footprint is more distributed along a diversity of material types.

Lowest:
MR3
238 kgCO$_2$e/m^2

Highest:
MR2
352 kgCO$_2$e/m^2

Figure 14: Project MR3, the least carbon-intensive “Open Space”

Figure 15: Project MR2, the most carbon-intensive “Open Space”

Frontages

Ten (10) out of ten (10) projects include a “Frontage” landscape. Carbon intensities range from **145 kgCO$_2$e/m^2 (HR1)** to **407 kgCO$_2$e/m^2 (MR4)**. This is the second largest range among landscape categories, suggesting that design decisions are particularly impactful. The average carbon intensity across all projects is **281 kgCO$_2$e/m^2**.

The least carbon-intensive Frontage (HR1) involves simpler landscape elements, resulting in lower upfront carbon emissions. HR1 is also the largest Frontage by area (1,333 m^2), allowing its carbon-intensive elements to be more distributed, reducing overall intensity. “Concrete Hardscape” (65%) and “Aggregate & Asphalt Hardscape” (29%) material types constitute over 94% of its carbon footprint.

The most carbon-intensive Frontage (MR4) includes large areas of subterranean soil to support multiple trees in hardscape on private property. As the smallest frontage in the study (140 m^2), its carbon is more concentrated, resulting in a higher intensity. Most of its emissions come from Soil & Amendments (47%) and Concrete Hardscape (27%), which together make up over 74% of the total footprint. While these elements contribute to upfront carbon, urban trees provide many well-established long-term benefits—including cooling, shade, stormwater management, and biodiversity—that are critical to resilient, livable cities.

Lowest:
HR1
145 kgCO$_2$e/m^2

Figure 16: Project HR1, the least carbon-intensive “Frontage”

Highest:
MR4
407 kgCO$_2$e/m^2

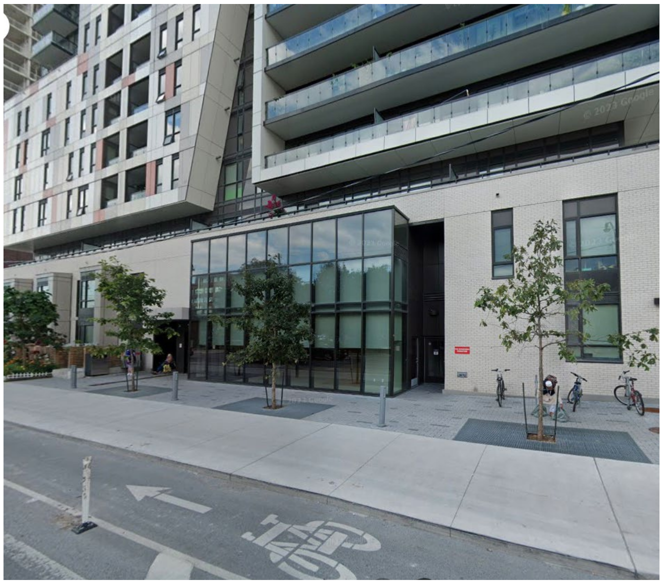


Figure 17: Project MR4, the most carbon-intensive “Frontage”

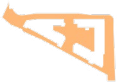
Streetscapes

Nine (9) out of ten (10) projects include a “Streetscape” landscape. Carbon intensities range from **243 kgCO$_2$e/m^2 (LR+MR1)** to **466 kgCO$_2$e/m^2(MR3)**. The average carbon intensity across all projects is **305 kgCO$_2$e/m^2**.

The least intensive Streetscape (LR+MR1) is located in a suburban setting. This results in a simpler construction with large softscape (sodded) areas. “Soil & Amendments” (62%) and “Concrete Hardscape” (23%) material types constitute over 85% of its carbon footprint.

The most intensive Streetscape (MR3) is in a downtown setting and includes trees in grates (hardscape), a City standard concrete sidewalk with paver band, and a large section of vehicular concrete paving at the building’s driveway. “Soil & Amendments” (43%) and “Concrete Hardscape” (29%) material types constitute nearly 72% of its carbon footprint.

Streetscape details can vary greatly depending on the location of the project. Suburban streets tend to be less “built up” and therefore less carbon-intensive than downtown hardscape streets.



Lowest:
LR+MR1
243 kgCO$_2$e/m^2

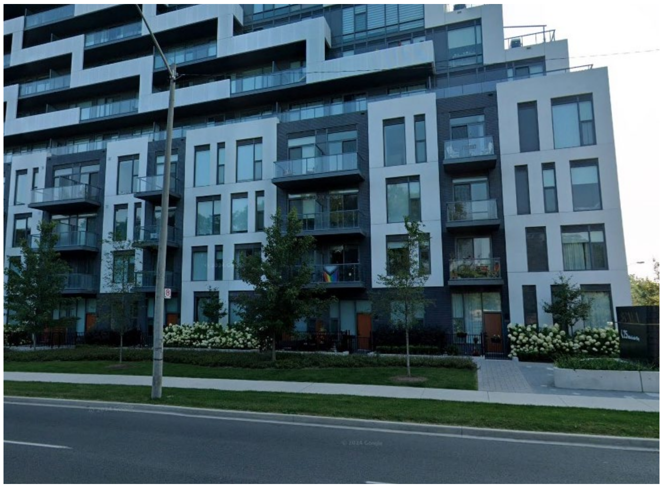


Figure 18: Project LR+MR1, the least carbon-intensive ‘Streetscape”

Highest:
MR3
466 kgCO$_2$e/m^2

Figure 19: Project MR3, the most carbon-intensive “Streetscape”

5.3 Material Type Emissions Per Project

The carbon impact of each project is largely influenced by the material types used in its landscape design. Figure 20 summarizes the carbon intensity of different material types across the case studies, highlighting their relative contributions to total emissions. This analysis focuses exclusively on landscapes within private property, with the “Streetscape” category excluded. The results provide insight into which materials drive the highest emissions and how they vary across different projects.

The figure below (Figure 20) demonstrates that in most projects, “Concrete Hardscape” and “Soil Amendments” are the most carbon-intensive material types. Concrete Hardscape is made up of various hard surface paving types such as precast unit pavers, natural stone pavers, and CIP concrete paving. This category is particularly carbon intensive due to the high embodied emissions of cement and the energy required for production, transport, and installation of heavy materials like concrete and steel reinforcement. Soil Amendments are made up of amended or imported soils for planting beds and mulch. This category contributes significantly to emissions because of the use of organic inputs like compost and mulch, which can release greenhouse gases during production and decomposition, as well as the energy associated with transporting bulk materials. Many other material types, ranging from 0–5 kgCO2e/m², have a relatively minor impact on their own.

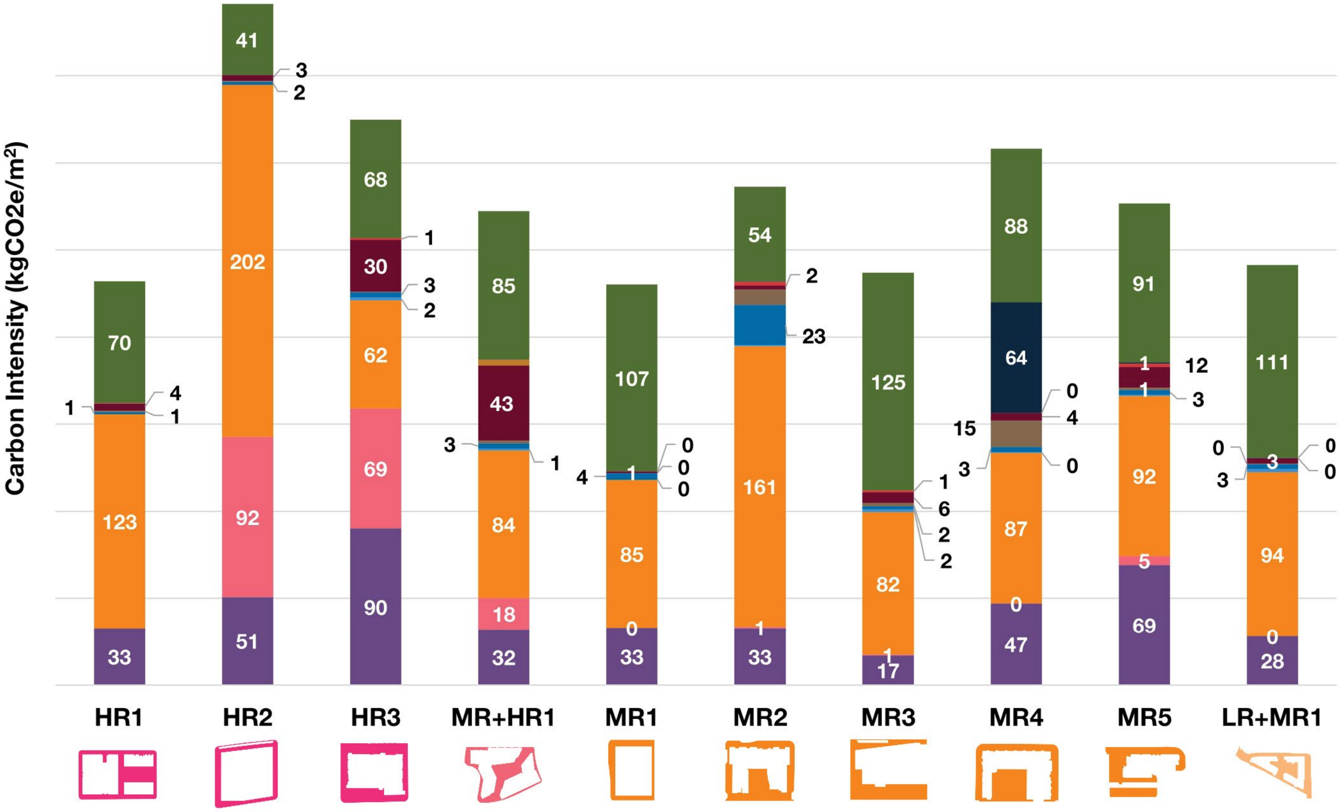


Figure 20: Relative Material Type Emissions Per Project

Figure 21 highlights the dominant carbon impact of “Concrete Hardscape” and “Soil Amendments” across all projects. Together, these materials account for more than half of the total carbon footprint, except in HR3 (40%). “Aggregate Asphalt Hardscape” ranks as the third most impactful material in most projects. Combined, these three material types contribute 68%–98% of each project’s total carbon footprint, underscoring their significant role in overall emissions.

The analysis also reveals that, in certain cases, “Brick Stone Hardscape” (HR2, HR3, MR+HR1), “Playground Athletic” (MR4), and “Infrastructure Subsurface” (MR+HR1, HR3) can be notable carbon contributors. In contrast, “Metal Wood Hardscape” (MR2, MR4) and “Furnishings” (MR2) have only minor impacts on select projects. Lastly, “Exterior Lighting,” “Site Elements,” and “Planting Accessories” are negligible across all ten projects, contributing 1% or less to total emissions.

For most projects, two material types, “Concrete Hardscape” and “Soil Amendments”, make up more than 60% of the carbon footprint.

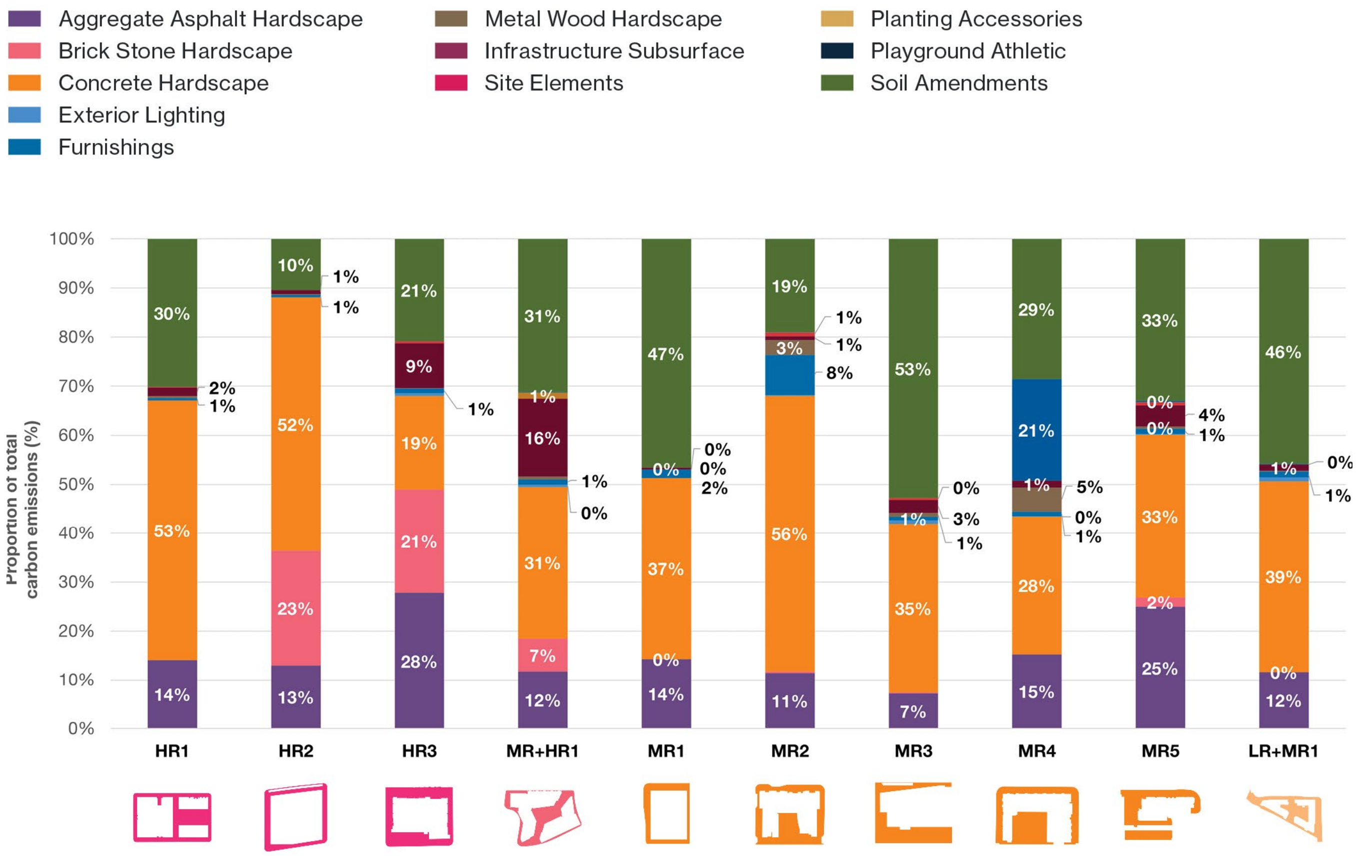


Figure 21: Material Composition Per Project

5.4 Material Type Emissions Per Landscape Category

Landscape categories vary in design, construction details, and material composition, which in turn influences carbon emissions from different material types. This section analyzes these emissions, using pie charts to illustrate the relative contributions of each material type within a given category. The charts represent the average material composition, calculated by aggregating all instances of each landscape category across the case study projects. Plant materials are excluded from this analysis, as they are addressed separately in the sequestration analysis (Section 5.7).

Across all sites, soil amendments were found to be more carbon intensive than concrete hardscape—underscoring the need to optimize streetscape details and material sourcing while still recognizing the essential co-benefits of street tree planting.

Circulation

For “Circulation” landscapes, the most carbon-intensive material is Concrete Hardscape (40%), followed by Aggregate Asphalt Hardscape (24%), together accounting for 64% of total emissions. This proportion is lower than in other landscape categories, indicating that emissions are more evenly distributed across various materials. Brick Stone Hardscape (13%) ranks third, bringing the combined contribution of the top three material types to 77% of the total carbon footprint for an average Circulation landscape.

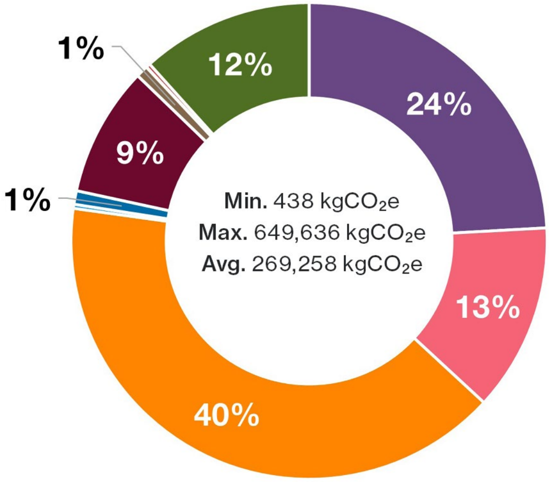


Figure 22: Total Carbon Emissions Based on Material Types for an Average “Circulation” Landscape.

Stoops

For “Stoop” landscapes, the most carbon-intensive material is Concrete Hardscape (48%), followed by Aggregate Asphalt Hardscape (30%), together making up 78% of total emissions. When including Soil Amendments (15%), these three materials account for 91% of the total carbon footprint, indicating that emissions in Stoop landscapes are highly concentrated in just a few material types.

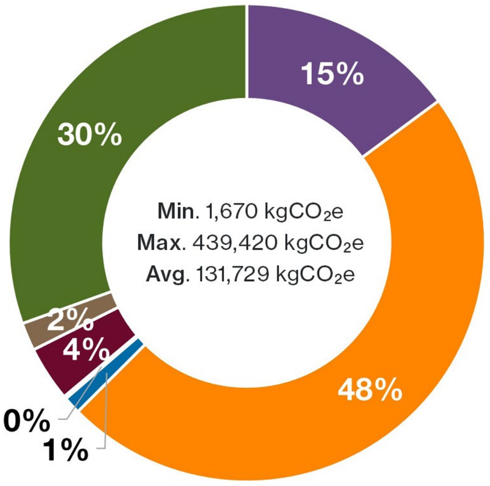


Figure 23: Total Carbon Emissions Based on Material Types for an Average “Stoop” Landscape.

Open Spaces

For “Open Space” landscapes, the most carbon-intensive material is Soil Amendments (43%), followed by Concrete Hardscape (29%), together contributing 72% of total emissions. Adding Aggregate Asphalt Hardscape (12%), the top three materials account for 84% of the total carbon footprint of an average Open Space landscape. This highlights the significant role of soil-related materials and hardscape elements in overall emissions.

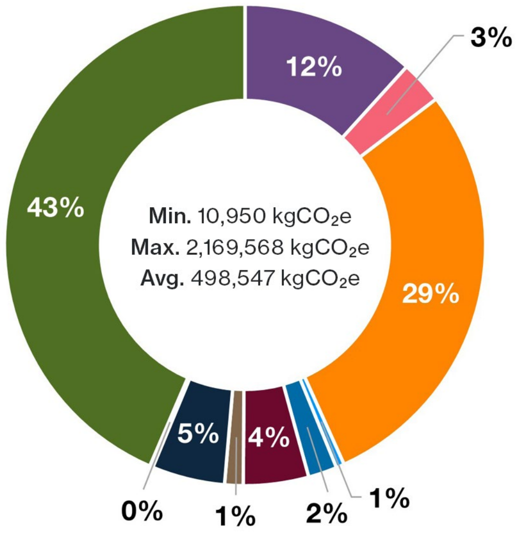


Figure 24: Total Carbon Emissions Based on Material Types for an Average “Open Space” Landscape.

Frontages

The Frontage material type analysis (Figure 25) demonstrates that “Concrete Hardscape” (42%) and “Soil Amendments” (29%). Together, they account for a combined 71% of embodied carbon in streets. The third most impactful material is “Aggregate Asphalt Hardscape” (13%). Combined, the top three materials account for a combined 84% of embodied carbon in streets.

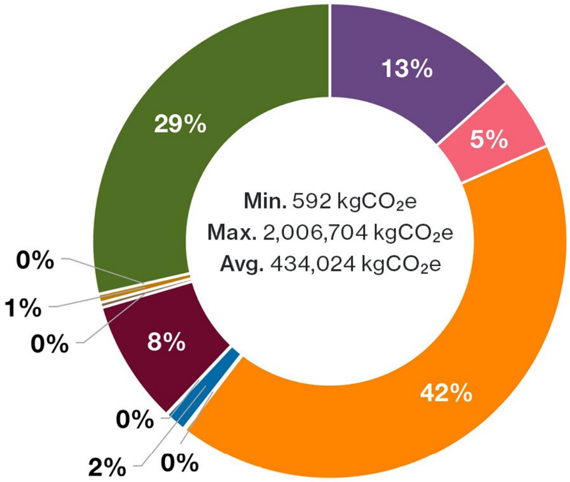


Figure 25: Total Carbon Emissions Based on Material Types for an Average Frontage

Streetscapes

The Streetscape material type analysis (Figure 26) demonstrates that “Soil Amendments” (51%) and “Concrete Hardscape” (30%) are the most carbon-intensive materials. Together, they account for a combined 81% of embodied carbon in streets. When “Aggregate Asphalt Hardscape” (11%) is added, the top three material streams contribute to a combined 92% of the carbon footprint of a typical streetscape.

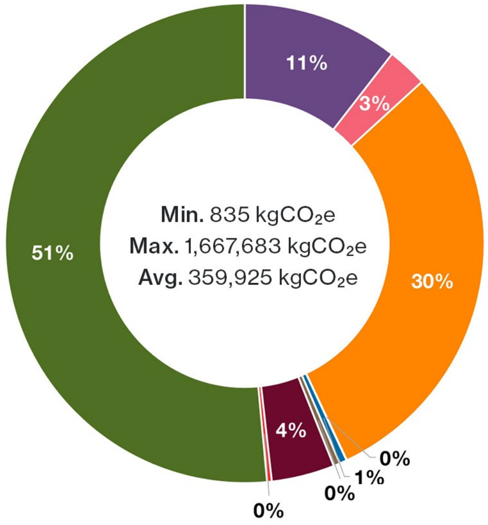


Figure 26: Total Carbon Emissions Based on Material Types for an Average Streetscape

5.5 Hardscape vs. Softscape Ratio

It is well understood that softscapes generally have a lower carbon footprint than hardscapes and, under the right conditions, can even act as carbon sinks. However, Figure 27 reveals that the case study projects are predominantly hardscaped, with hardscape areas ranging from 67% to 100% of the total landscaped area. As a result, softscapes play a limited role, making up only 0% to 33% of the landscape. This trend reflects the urban contexts of the selected projects, where buildings occupy most of the site, leaving little space for unencumbered landscape areas. The remaining open spaces are often hardscaped to support access and servicing needs.

It is important to note that these results pertain specifically to the landscape area of each project. They do not account for the building footprints or the public “Streetscape” component beyond the property line.

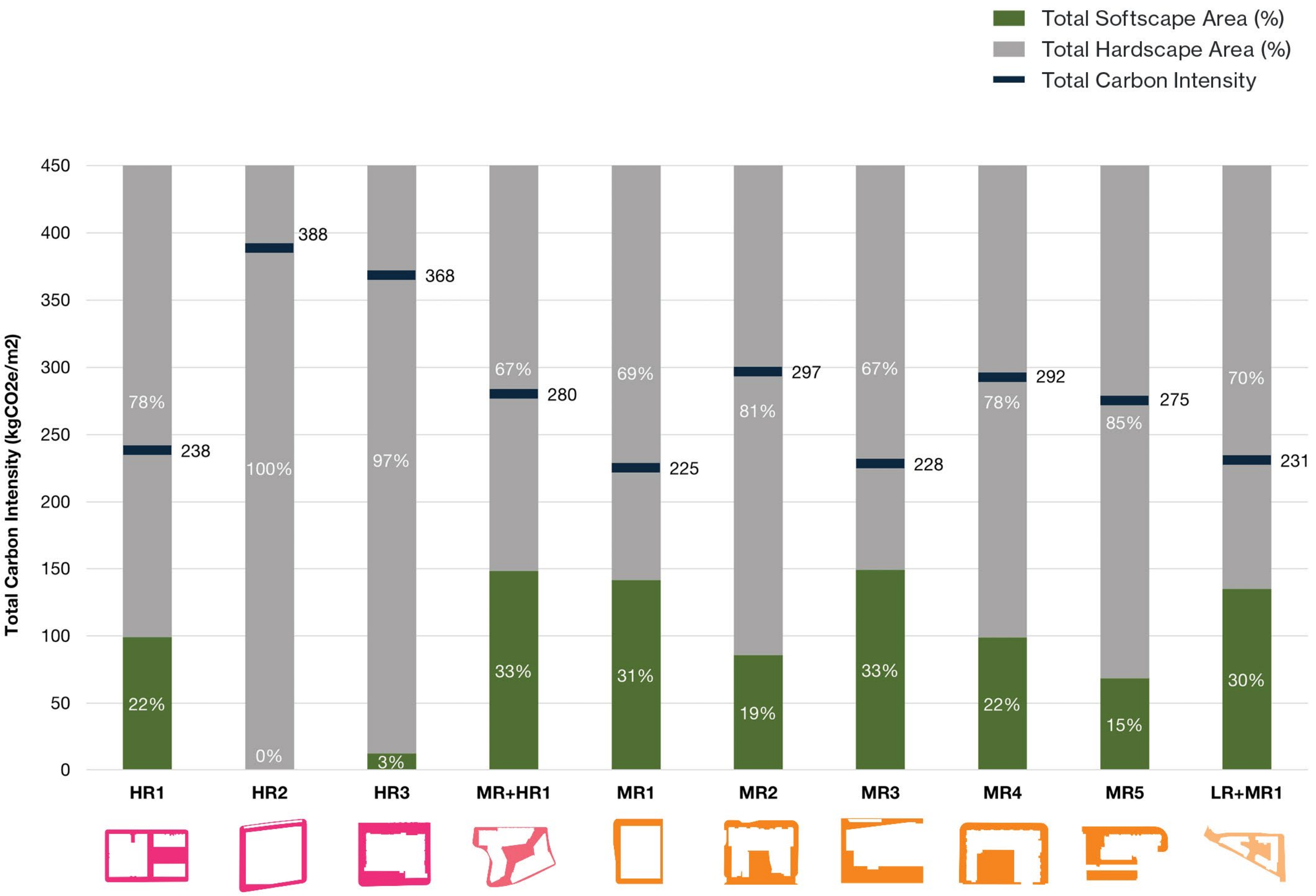


Figure 27: Proportion of Hardscape and Softscapes Within the Case Studies

Further analysis mapping the proportion of hardscape against total carbon intensity for each project shows a strong correlation ($R^2 = 0.8035$) (Figure 28). The data indicates that projects with higher hardscape coverage tend to have higher carbon intensity. Notably, the most carbon-intensive projects (HR2 and HR3) also have the highest hardscape coverage (100% and 97%), reinforcing the connection between extensive hardscape use and increased emissions.

Generally, the more a site is covered with hardscape, the more carbon-intensive it is.

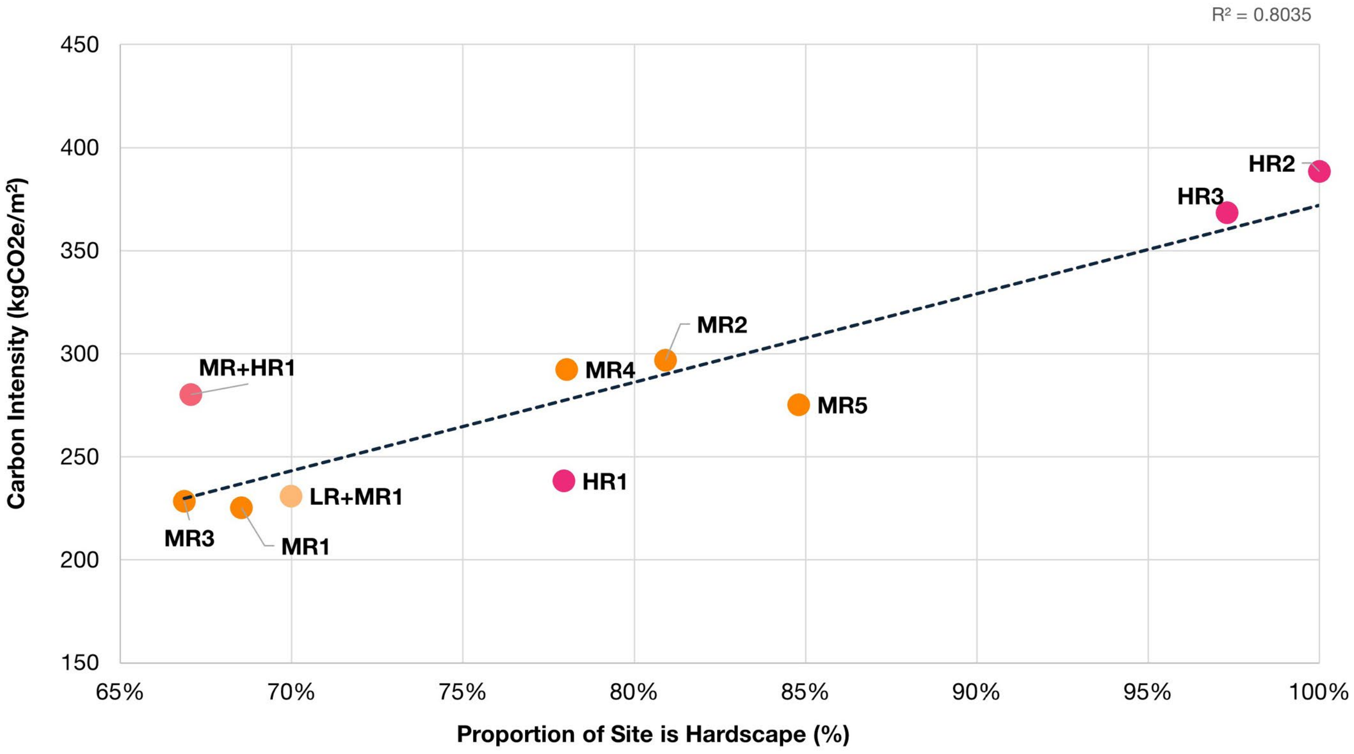


Figure 28: Carbon Intensity VS Hardscape Proportion

5.6 Carbon Sequestration Per Project

The Pathfinder tool assumes carbon sequestration from plant material over a 60-year period, based on species, quantity, growth zone, and maturity. It includes projected carbon uptake from trees, shrubs, perennials, and lawns using data from the USDA Forest Service and the Carbon Conscience dataset. While decomposition is factored in, long-term soil carbon storage is not, making these estimates conservative (source: CPD_Pathfinder-3.0 Methodology Report).

Figure 29 summarizes the carbon sequestration intensity per project, with results ranging from **-26 kgCO$_2$e/m^2 (MR1)** to **-3 kgCO$_2$e/m^2 (HR2)**, and an average sequestration intensity of **-11 kgCO$_2$e/m^2**.

The project with the most carbon sequestration intensity is MR1 (-26 kgCO$_2$e/m^2). It is a rare example where trees are included in all its landscape categories. Open planters also offer opportunities for other types of plantings such as shrubs and perennials.

The project with the least carbon sequestration intensity is HR2 (-3 kgCO$_2$e/m^2). This project does include some trees, but they are in grate details since the totality of the site is hardscape.

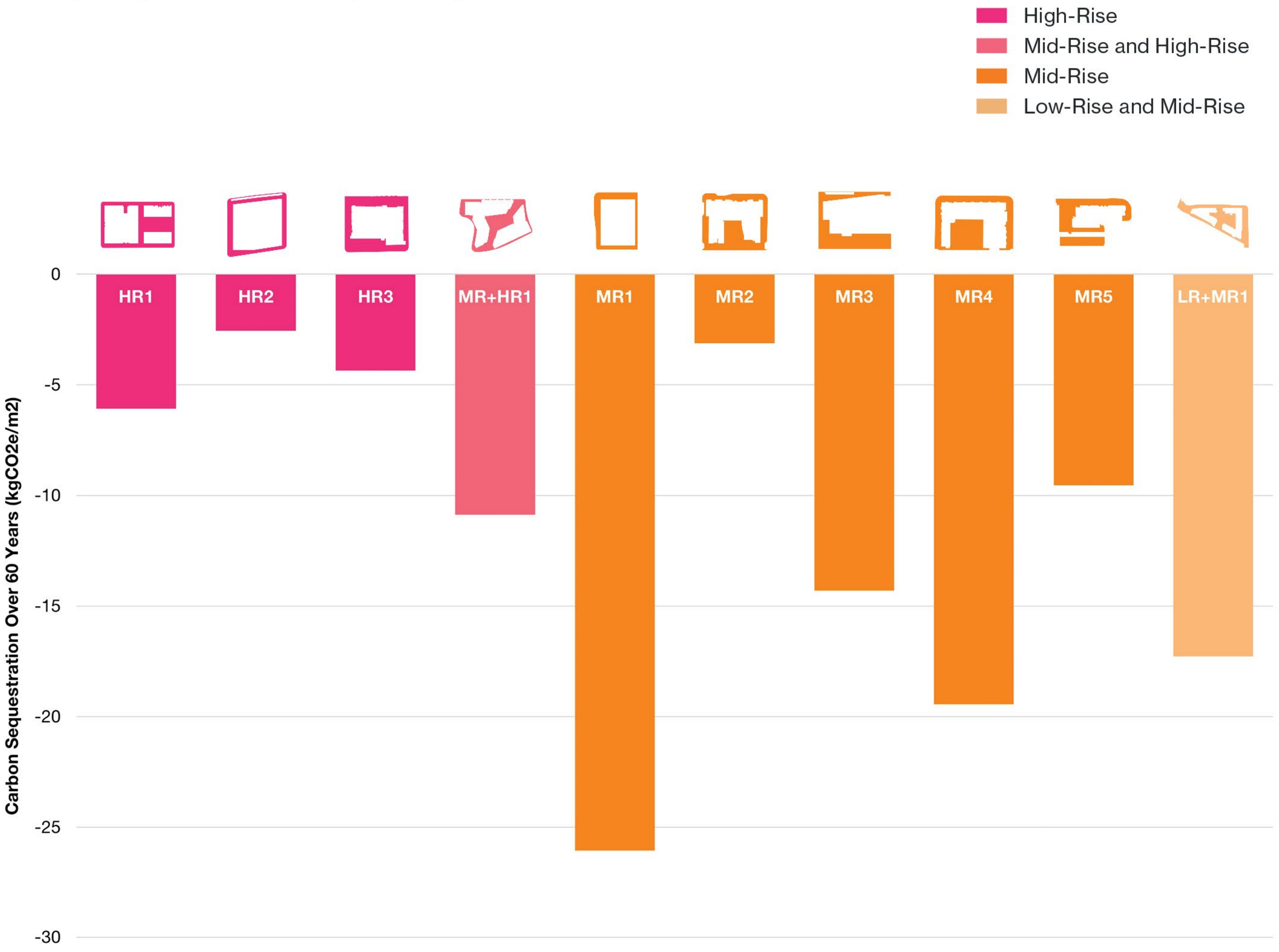


Figure 29: Total Carbon Sequestration Per Project

It is important to note that carbon sequestration is minimal across all projects, accounting for less than 5% of net total emissions in most cases (Figure 32). The project with the highest proportional sequestration is MR1, at approximately 12%. This reflects the limited impact of sequestration within the constrained planting areas typical of dense urban development. In these contexts, avoiding embodied carbon up front—particularly through reductions in hardscape—is far more effective than relying on planting to offset emissions. However, this does not diminish the broader value of trees and greenspaces, which continue to provide critical environmental and social co-benefits and should remain an integral part of urban design. More research is needed on the sequestration potential of urban street trees and plantings to inform future LCAs.

Figure 30: Project MR1, the project with the most carbon sequestration potential

Figure 31: Project HR2, the project with the least carbon sequestration potential

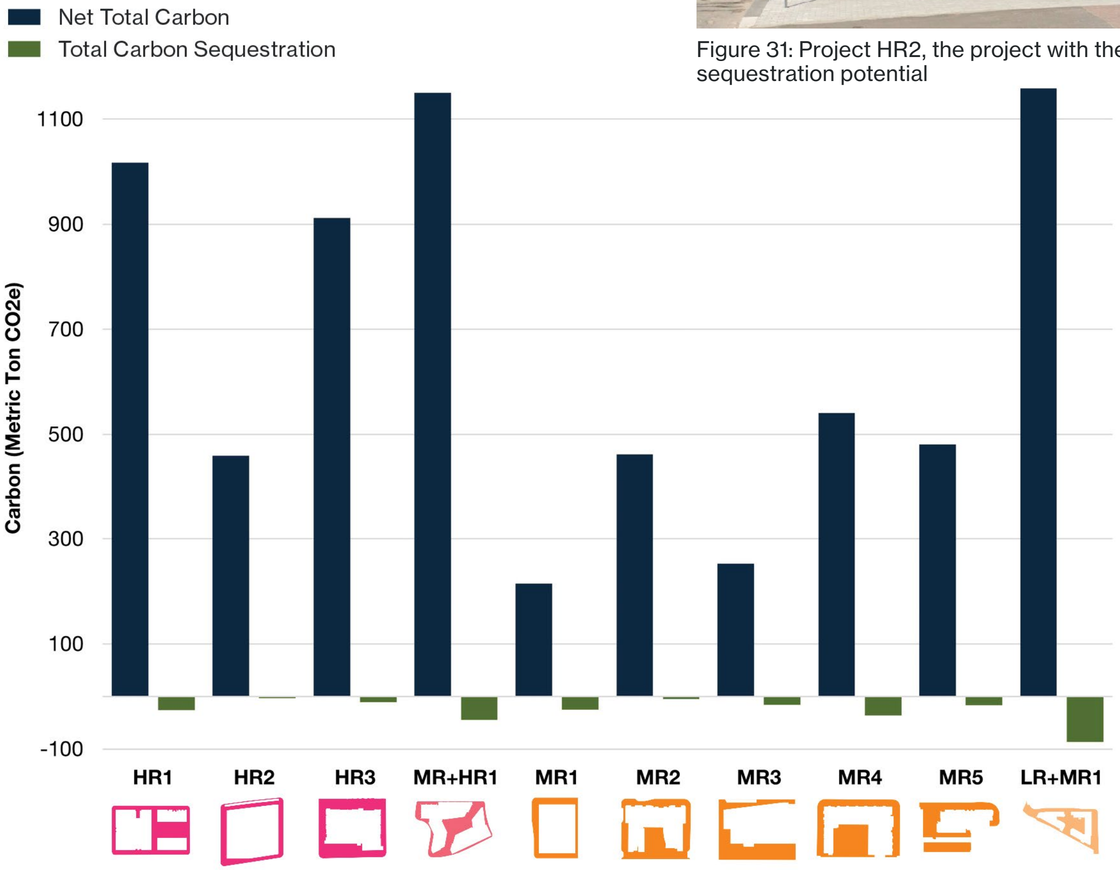


Figure 32: Total Carbon Emissions versus Total Sequestration Per Project

5.7 Years to Climate Positive

While the “Years to Climate Positive” metric is a key feature of the Pathfinder tool, the results of this study suggest it is less relevant for most mid- and high-density development sites in large Canadian cities because of the limited space available for sequestration planting in dense urban sites. In many cases, the tool returned an “infinite” timeline to carbon positive (Figure 33), or the values were so large (e.g., 1.5 million years) that the metric became impractical to use.

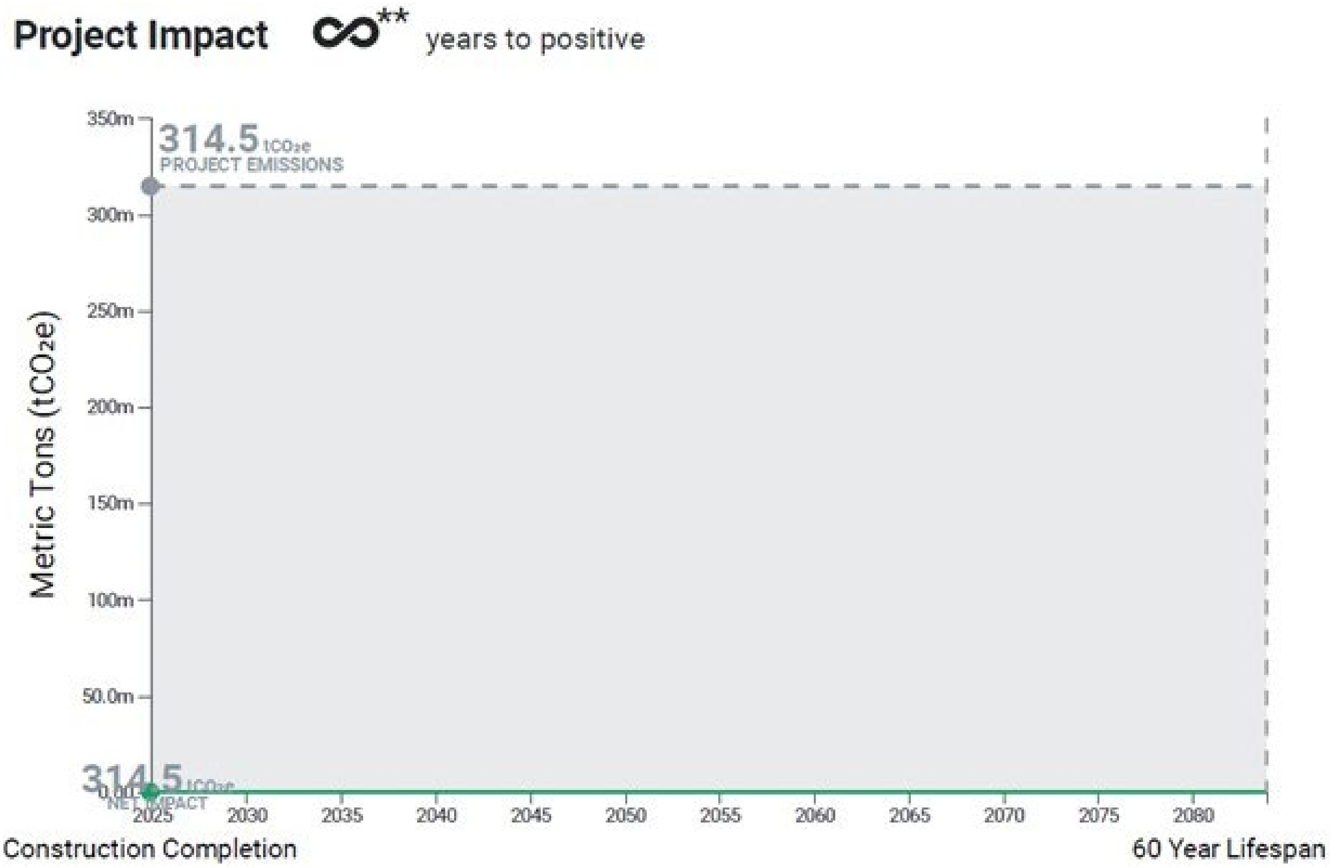


Figure 33: Example of an “infinity years to positive” result in Pathfinder

5.8 Limits to the Analysis

This study is based on numerous assumptions, some of which have minor effects, while others can significantly influence the findings. The following is a list of identified limitations, along with insights on their potential impact on the study's results.

Changes since SPA

- Since the study uses Site Plan Application drawings, it is likely that further changes have been made through the latter stages of design. As demonstrated through this study, changes in construction detailing and material selection can have important impacts on the carbon footprint of a project. In addition to changes to the design before and during construction, it is also common for changes to occur once a project is handed off to the owner. These changes have not been captured in this study.

Various Drafters

- The drawing sets used in this study were produced by different landscape architectural firms, resulting in varying levels of clarity, completeness, and material specification. Site Plan Approval (SPA) drawings can differ significantly in the level of detail provided—particularly for landscape components—which may specify material categories rather than exact products. Leveraging DTAH's experience with the preparation of such drawing sets, the authors made every effort to produce consistent and accurate quantity takeoffs across all projects.

Quantity Take-Off Accuracy

- Quantity take-offs were completed using PDF documents, generally the latest available set of Site Plan Application (SPA) drawings. While this approach limits precision, it ensures consistency across all analyzed projects, rather than using CAD for some and PDFs for others. Compared to other limitations, this is likely a minor constraint, as it maintains methodological uniformity throughout the study.

Low-Carbon Redesign

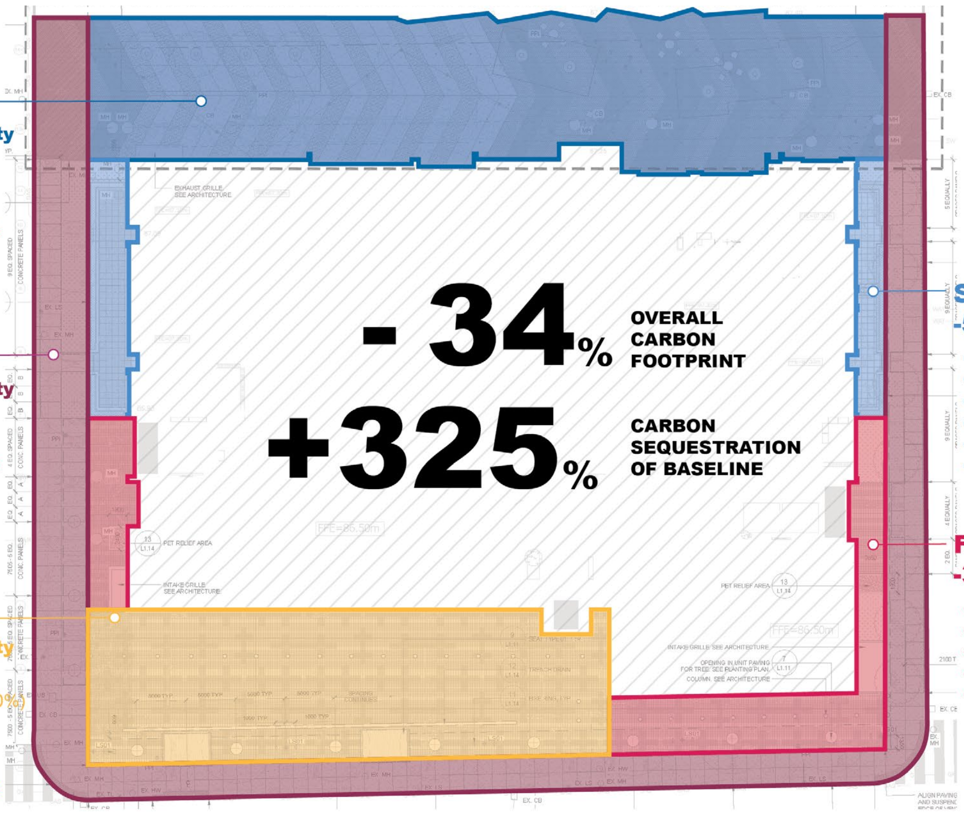
6

6.1 Low-Carbon Redesign Introduction

This chapter explores a theoretical low-carbon redesign of one case study project to test how alternative material choices, construction details, and transportation assumptions could significantly reduce its carbon footprint. The goal is to push the boundaries of current design practices, demonstrating what is possible if carbon reduction were prioritized, independent of the typical constraints of the development approvals process. While the original design intent will be maintained as much as possible, the focus will be on innovative low-carbon solutions.

HR3 has been selected for this exercise as it is one of the most carbon-intensive projects (2nd highest out of 10) and includes all five landscape categories, making it an ideal case for exploring comprehensive carbon reduction strategies.

Figure 34 below summarizes the key assumptions and results for each landscape category as well as for the overall project. More detailed descriptions of the assumptions and results are included in the next two sections.



CIRCULATION
-24% Carbon Intensity
- Open Planter (30%)
- low carbon unit paver
- Wood base/footings
- Recycled aggregate base
- Salvaged wood material

STREETSCAPE
-21% Carbon Intensity
- Open Planter
- Low carbon unit paver
- Recycled aggregate base

OPEN SPACE
-44% Carbon Intensity
- Micro forest (30%)
- Low carbon unit paver (10%)
- Stabilized crushed stone paving (60%)
- Wood base/footings
- Recycled aggregate base
- Salvaged wood material

STOOP
-57% Carbon Intensity
- Removal of brick wall
- Shrub screening
- Low carbon unit paver
- Wood base/footings
- Recycled aggregate base
- Salvaged wood material

FRONTAGE
-32% Carbon Intensity
- Open planters
- Low carbon unit paver
- Wood base/footings
- Recycled aggregate base
- -alvaged wood material

Figure 34: Summary of design changes and results for the theoretical low-carbon redesign of HR3

6.2 Assumptions

The following is a complete list of the modifications that were made to the base design to reduce its carbon impact. They range from "overall" changes that apply to all landscape categories to others that are unique to a specific landscape category.

Overall

- Assumes the reuse of recycled concrete and brick from demolished buildings.
- Assumes the salvage and reuse of wood materials from the site.
- Use of a precast concrete unit paver product with a 12% lower carbon footprint (Product: Unilock EcoTerra)
- Use of a 100% recycled aggregate base.
- New open planter detail (without edge) that includes planting with perennials, grasses, deciduous small shrubs, deciduous medium shrubs, deciduous large shrubs, and amended import soil (increased).
- The volume of amended import soil is considered shared between trees and understory plantings in the open planter.
- Modular suspended pavement system is removed between trees in grate since open planter detail is introduced.

Open Space (POPS)

- 30% of the space is changed into a micro forest. Understory plants for the micro forest are assumed to include 1/3 small shrubs, 1/3 medium shrubs and 1/3 large shrubs. The microforest includes two additional trees.
- 10% of the remaining paved surface is changed to low-carbon unit pavers (walkways).
- 60% of the remaining paved surface is changed to stabilized crushed stone paving with an assumed 100mm depth and 150mm compacted aggregate base underneath.
- Seating is modified to use a wood deck structure, mitigating the need for a CIP concrete base.

Stoops

- The assembly of concrete brick walls including concrete wall, concrete footing and compacted aggregate base was replaced by shrubs (to form a hedge) with amended import soil.
- Precast concrete unit pavers were replaced with a low-carbon unit paver (see "Overall").
- Metal gate is replaced with a wood gate.

Circulation (Laneway)

- 30% of the hardscape was changed to open planters.
- Precast concrete unit pavers were replaced with a low-carbon unit paver (see "Overall").
- Furnishings changed to use repurposed salvaged wood made by a hyper-local fabricator.

Streetscape

- Trees in grates were changed to trees in open planters (see "Overall" for further detail).
- Precast concrete unit pavers were replaced with a low-carbon unit paver (see "Overall").

Frontage

- Trees in grates were changed to trees in open planters (see "Overall" for further detail).
- Precast concrete unit pavers were replaced with a low-carbon unit paver (see "Overall").

The figures below illustrate a “before and after” view of HR3. The first image is a Google Street View screenshot of the site as it exists today. The second image is a visualization of the same location, reimagined through the lens of the theoretical low-carbon redesign, shown from the same perspective.

Figure 35: Before - Screenshot of a July 2023 Google Streetview image of the site. A person has been added for scale.

Figure 36: After - Visualization of the same site imagining how the theoretical low-carbon redesign would look from the same vantage point.

6.3 Results

Figure 37 summarizes the considerable impacts of the low-carbon redesign of HR3. Carbon intensities now range from 325 kgCO$_2$e/m^2 to 149 kgCO$_2$e/m^2. The project's total carbon intensity decreased a total of 34%, from 368 kgCO$_2$/m^2 to 242 kgCO$_2$/m^2. This redesign shifts HR3 from being the second most carbon-intensive project to the sixth out of ten, demonstrating the potential of low-carbon design strategies to meaningfully reduce emissions.

The greatest reduction in carbon intensity occurred in the Stoops category, with a 57% decrease. In contrast, the smallest improvement occurred in Streetscapes, with a 21% reduction, which is expected given the limited design flexibility within the right-of-way (ROW) due to City standards. Total carbon sequestration increased significantly by 193%, though it remains a relatively small factor compared to the project's overall emissions. (Note: The total project results exclude the "Streetscape" category from the analysis)

While this study focuses on carbon, it's important to note that many of the redesign strategies—such as reducing hardscape and increasing planting—also offer broader environmental and social co-benefits. These include improved stormwater management, urban heat island mitigation, enhanced biodiversity, and more comfortable and livable outdoor spaces.

Overall, the low-carbon redesign results are promising, demonstrating that significant reductions in urban landscape emissions are achievable by re-evaluating conventional design strategies and material assemblies. This exercise highlights the potential for more sustainable approaches without compromising functionality.

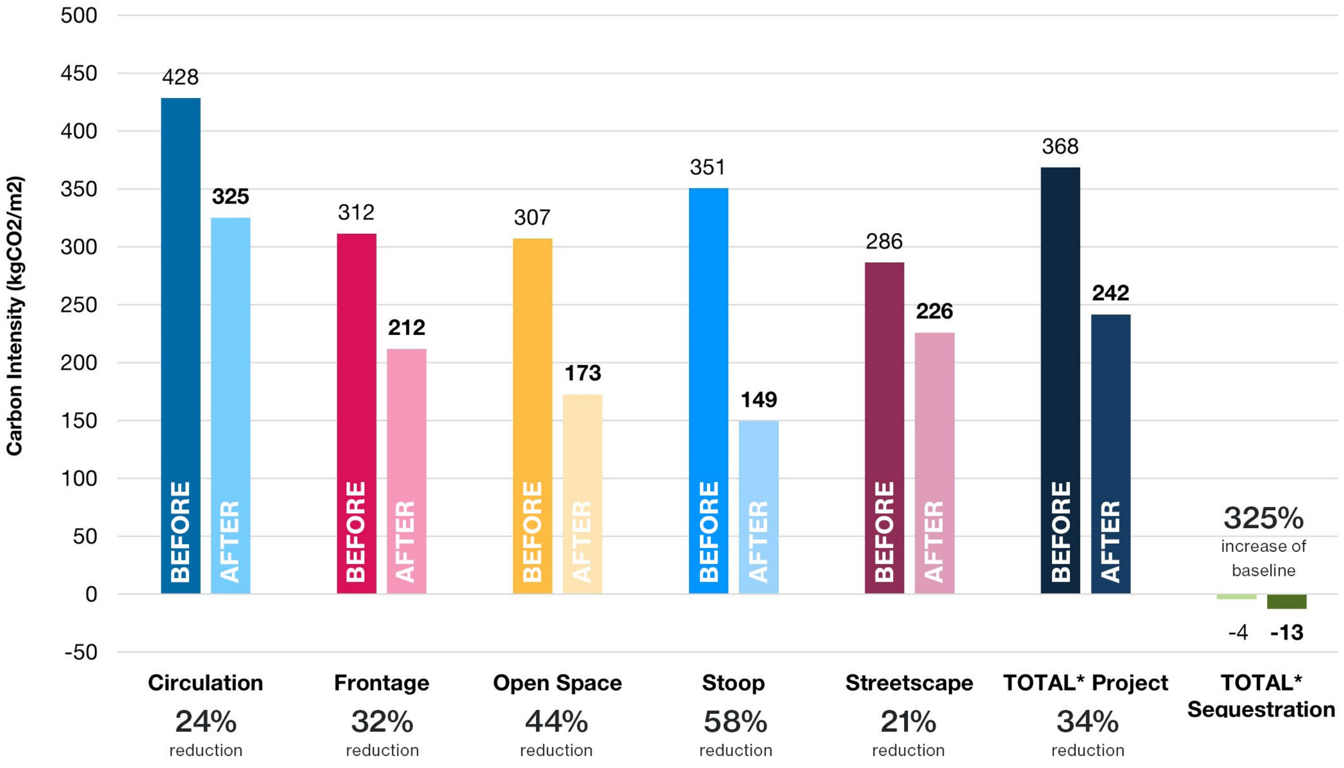


Figure 37: Original Design Compared to Low-Carbon Redesign of HR3

Conclusions

This chapter presents key conclusions based on the study's findings, offering guidance for practitioners working on urban development projects across Canada. The insights can also support policy development and help establish carbon targets for landscape design.

7

7.1 Introduction

This study delivers the first city-scale benchmark of embodied carbon in Canadian urban landscapes. Analysis of ten Toronto developments shows that net landscape intensities fall between 225-388 $kgCO_2e/m^2$, with three material streams - Concrete Hardscape, Soil Amendments, and Aggregate Asphalt - responsible for roughly 85% of total emissions (see Section 5.3). Hardscape coverage is the strongest predictor of carbon intensity ($R^2 = 0.80$, Fig. 30), while vegetation offsets rarely exceed five percent of project totals (see Section 5.6). A theoretical redesign validated the opportunity: re-thinking details and materials lowered overall intensity by 34% - and by more than 50% in individual categories such as Stoops (see section 6.3).

These findings lead to two action tracks:

1. Project-level design strategies that any practice can adopt today, and
2. Municipal policy pathways that enable consistent, scalable reductions across an entire city.

7.2 Project-Level Design Strategies

Earlier is Better

This study reinforces the importance of applying life cycle analysis (LCA) and carbon accounting at the earliest stages of a project. The low-carbon redesign exercise demonstrated that significant reductions in embodied carbon were achievable when design strategies were rethought from the outset. These reductions were driven by changes in site layout, material selection, and construction approaches - decisions that are most effective when made early in the design process. Once key elements such as hardscape materials or subbase systems are locked in, opportunities for meaningful carbon savings become more limited. Prioritizing carbon considerations from the beginning allows for more efficient, cost-effective, and environmentally impactful outcomes. Integrating an LCA or carbon accounting lens early on gives designers and project teams the greatest ability to influence performance and drive low-carbon results.

Reduce Hardscape - the Fastest Win

Carbon intensity rose almost in lock-step with hardscape coverage ($R^2 = 0.80$). Swapping just 10% of paving for planting in frontage areas cut emissions by roughly one-fifth. The benefit came chiefly from avoiding concrete and asphalt, not from sequestration (< 5 % of totals). By prioritizing generous soil volumes, long lived species and biochar-rich soils, added softscape is able to deliver both carbon relief and urban-heat, stormwater, and biodiversity co-benefits.

Target the Big Three Material Streams

Three Material Types - Concrete Hardscape, Soil Amendments, Aggregate Asphalt - produced ~85% of total emissions. More specifically, concrete unit pavers, compacted aggregate bases and amended imported soil were the highest emitting individual materials.

Targeting these high-impact material types and specific materials through standard detail and specification changes, alternative product and material options, and policy incentives can lead to substantial reductions in overall embodied carbon in urban landscapes.

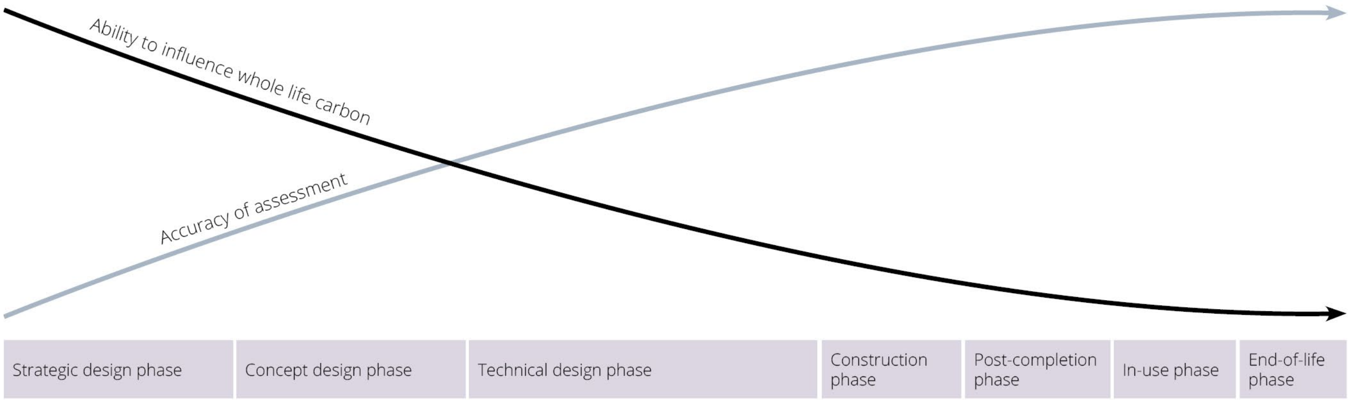


Figure 38: As the project progresses, the ability to influence whole-life carbon decreases but the accuracy of data increases. (Source: RICS)

Think Local

The study highlights that transportation emissions - particularly for bulk and heavy materials - can significantly influence a project's overall carbon footprint. Sourcing locally is a practical way to reduce A4 (transportation to site) emissions and lower embodied carbon.

Using local materials not only reduces emissions but also improves delivery reliability, strengthens regional supply chains, and increases transparency around product origin and environmental performance. As demonstrated in the study's low-carbon redesign, even modest changes in material selection and sourcing can lead to meaningful reductions in carbon intensity.

Design for Low-Maintenance Operations

High-maintenance elements - irrigated turf, short-lived annuals - carry hidden operational carbon over the 60-year life-cycle modelled in Pathfinder. Native meadows, no-mow zones, and resilient plant communities lower these downstream emissions and reduce total project carbon long after substantial completion.

Tackle the Carbon Cost of Soil Amendments

The study finds that in some landscape categories Soil Amendments (including imported and amended soil and mulch) can be more carbon intensive than Concrete Hardscape. This counter intuitive result reflects the large volume of imported soil required to support urban trees. This highlights the need to refine standard details, seek verified lower-carbon soil and mulch sources, and reduce transportation distances.

However, it's important to note that these figures do not account for the many co-benefits of urban tree planting - such as shade, cooling, biodiversity, and long-term sequestration - which are critical to urban design. This recommendation is not a case against urban trees, but a call to optimize how their planting components are specified to enhance their carbon performance and support important co-benefits.

Rethinking Materials

Achieving low-carbon landscapes doesn't require sacrificing design intent - it requires rethinking material choices. In many cases, lower-carbon alternatives are already available and as the market responds to growing demand, more options will emerge. Where simple material or product substitutions can be made - such as lower carbon unit pavers instead of standard pavers - these choices should be prioritized.

However, in other cases, landscape architects will need to challenge conventional norms and explore new construction methods and material innovations to reduce emissions. This may involve rethinking hardscape detailing and assemblies, using more reclaimed or recycled materials, or integrating hybrid softscape solutions where possible.

By pushing boundaries and making informed material choices, designers can significantly lower embodied carbon while still delivering functional, durable, and aesthetically compelling landscapes.

Together, these actions map a realistic path to 25-40% embodied-carbon reduction for typical Canadian urban development sites.

7.3 Municipal Policy Pathways

This study provides a foundation for Canadian municipalities to begin integrating embodied carbon considerations into landscape policy, guidelines, and development review processes. While the primary focus was not to set specific carbon targets, the findings offer practical insights for how cities can support the transition to lower-carbon landscapes through thoughtful policy design.

By embedding carbon accounting into development approvals and design standards, cities can promote consistency, close performance gaps between projects, and normalize carbon-conscious landscape design. The following policy recommendations are intended to support municipal governments seeking to establish or strengthen embodied carbon requirements in their planning and regulatory frameworks.

Introduce Carbon Accounting into the Development Review Process

Municipalities can encourage or require carbon assessments as part of the landscape approvals process. This can be implemented in phased or tiered approaches to suit different project types and readiness levels within the industry.

Example policy approaches include:

- *Encourage Demonstrated Improvement:* Require applicants to show an “as-designed” and “improved” version of their landscape design, demonstrating how carbon intensity was reduced - without prescribing fixed targets.
- *Set Relative Reduction Targets:* Require projects to demonstrate a minimum percentage reduction in embodied carbon compared to a city-defined baseline. This baseline could be based on average carbon intensities from studies like this one
- *Require Full Carbon Accounting Submissions:* Mandate that projects submit a carbon impact report - using tools such as Pathfinder or equivalent - that outlines carbon intensity over a standard time frame (e.g., 60 years), even if no minimum threshold is enforced initially.

These approaches can be implemented independently or in combination, depending on local policy goals and industry capacity.

Set Practical and Measurable Carbon Targets

As policy matures and municipalities build confidence with carbon accounting tools and data, they can move toward setting baseline carbon intensity targets (e.g., in $kgCO_2e/m^2$) for private landscapes. These targets could apply to the full private landscape area of a site, avoiding overly complex breakdowns by landscape category. Over time, more granular targets by site type or land use could be developed.

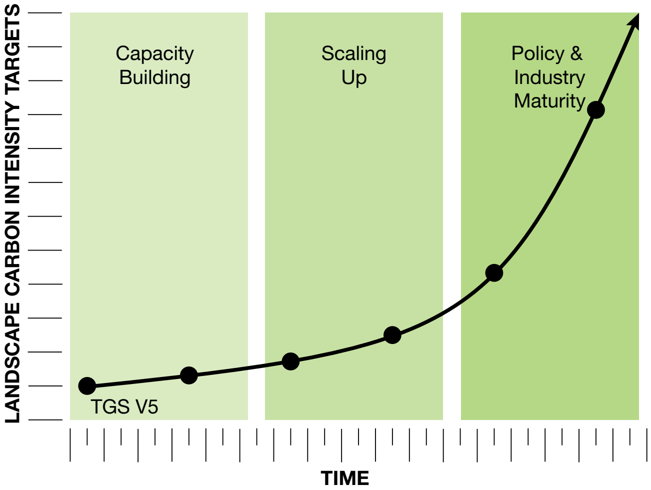


Figure 39: Progression of carbon intensity targets over time, aligned with policy development and industry readiness. As the landscape architecture community builds capacity, targets gradually scale up, culminating in a mature phase where policy and industry practices are aligned around measurable performance expectations.

Standardize Methodologies and Submission Requirements

Clear guidance is essential to ensure consistency in how carbon is calculated and reported. Municipalities should develop terms of reference for acceptable tools, inputs, and assumptions used in carbon accounting. A standardized submission format - such as a “Landscape Carbon Impact Statement” - can help streamline reviews and improve transparency. These submissions could also be made publicly accessible through development application portals.

Create a Municipal Carbon Reference Library

As carbon data becomes more available, municipalities can play a leading role in curating and sharing it. By reviewing a wide range of project submissions, cities will gain insight into effective strategies, assemblies, and material substitutions being used by practitioners.

A centralized, open-access library of typical landscape assemblies (e.g., paving systems, tree pits, soil cells, retaining walls) with associated carbon footprints can help design teams make informed decisions earlier in the process. This resource would also reduce duplication of effort and accelerate learning across the industry.

Invest in Staff Training and Internal Capacity

To implement carbon-focused landscape policy effectively, municipalities must build internal knowledge. Staff involved in development review and inspections should be trained to understand landscape life cycle assessments (LCAs), carbon reporting tools, and the implications of design changes on project emissions.

Investing in tools, datasets, and ongoing professional development will allow staff to provide meaningful guidance, enforce policy objectives, and contribute to a culture of low-carbon design.

Manage the Public Realm Separately

Carbon targets should focus on areas where applicants have design control. Public rights-of-way, which are typically governed by municipal standards, should be addressed separately through updates to standard details and specifications for municipal infrastructure.

Report Progress and Recognize Success

Transparent reporting on carbon reductions achieved through landscape policy can help build public support and reinforce the value of these efforts. Municipalities should track key performance indicators (e.g., average carbon intensity per project) and share results annually.

Recognition programs - such as design awards or case study showcases - can also highlight leadership in carbon-aware landscape design and inspire continued innovation across the industry.

Establish Oversight Proportional to Policy Scope

Define the level of oversight needed to ensure compliance with carbon accounting standards—balancing rigor, feasibility, and administrative effort for both municipal staff and applicants.

Track and Report Policy Outcomes

Use standardized reporting templates to collect carbon data from development applications. This enables cities to monitor performance, assess policy effectiveness, and communicate impact over time to residents and elected officials.

Support Innovation and Material Testing

Encourage pilot projects and material trials in collaboration with industry and academic partners. Document results to build evidence for emerging low-carbon strategies, such as biochar soil amendments.

Plan for More Comprehensive LCA Approaches

Develop a phased roadmap toward full life cycle (cradle-to-grave) carbon accounting. Begin with simplified assumptions and refine over time as tools, data, and industry familiarity evolve.

Promote Circularity

The study shows Concrete Hardscape and Aggregate Asphalt are consistent, high-carbon contributors. Municipalities can curb these emissions by embedding circular-economy principles into policy:

- Require recovery and reuse plans for demolition and redevelopment permits, encouraging projects to specify reclaimed concrete, recycled aggregate, and salvaged paving.
- Set clear performance specs that recognise recycled-content materials and make them acceptable for approvals and public procurement
- Learn from leading jurisdictions - Sweden, France, Hamburg, Copenhagen - where material-reuse mandates and digital exchanges keep construction waste in circulation.

By formalising these measures, cities can cut embodied carbon, reduce waste, and build local markets for low-carbon landscape materials.

By implementing these strategies, municipalities across Canada can lead a coordinated shift toward lower-carbon urban landscapes, supporting national climate goals while improving long-term environmental performance at the local level.

Appendix

Appendix A: Technical Assumptions

The following assumptions apply to all ten sites that were studied:

Area Take-Offs:

- All areas are calculated to 0.0 accuracy.
- Columns are not subtracted from the overall ground floor area (their footprints are included even though they take away ground floor area.

Transportation:

- Although the exact distances can vary greatly, we believe the following assumptions reflect the typical construction scenario that a landscape architect using this tool would most likely use.
- Local transportation (160 km radius) has been assumed for the following materials: mulch, amended import soil, sod, perennials, shrubs, trees, compacted aggregate base, stabilized crushed aggregate paving, sand setting bed, precast unit pavers, cast-in-place concrete paving, cast-in-place sub-slabs, modular suspended pavement systems, cast-in-place footings, safety surface pea gravel, precast stairs, asphalt paving and CMU block wall.
- Regional transportation (800 km radius) has been assumed for the following materials: rebar, stone unit paving, lighting, fencing, bollards, metal poles, reinforcements, fasteners, decking, ADA truncated dome pavers/ Tactile Walking Surface Indicator (TWSI), site furnishings and any other materials.

Exclusions:

- All architectural features (i.e. air intake and exhaust grilles) are excluded from the area calculations.
- Lighting drivers and transformers are not included in the carbon calculations.
- Electrical scope is not included except outside of light fixtures.
- Manhole covers are only new covers and do not account for any existing covers present on site.
- Garage entrance/ back loading area is not included in the area takeoff.
- Only fixed elements are included in the material take-offs - elements like movable tables and chairs have not been captured in this scope.

Planting:

- All Shrubs are noted as #3 containers and perennials are noted as #1 containers.
- All trees are balled and burlapped (B&B)
- The perennials/ perennial grasses are assumed to be 100% native plants.
- Planting accessories such as tree watering bags have not been included due to their negligible carbon footprint.
- Every tree planted has 30 m3 of soil per tree. It is assumed that other plant material would share the tree's soil volume.
- Rigid insulation is not included as part of the Pathfinder tool and is therefore not included in the calculations.

Furnishings:

- Site Furnishings (bike rings and prefabricated benches) have been based on Maglin's Environmental Product Declarations (EPDs).
- Carbon impacts of all play equipment (climber, spinner, slider) are based on Kompan's EPDs.
- For furnishings that do not have EPDs, a mean carbon impact value is used instead. These mean values are included in EPDs for other similar products.
- Bike racks within private property are assumed to be Maglin Iconic Bike Rack
- Bike racks within the public ROW are represented by Maglin MBR 0200 Series which are similar in appearance to the City of Toronto standard bike ring.
- All benches unless otherwise indicated are assumed to be the 2300 Series Maglin Bench.
- Footings of light bollards are not included in Pathfinder and are not included in this study.

Subsurface

- Soil Cells are not currently included in the Pathfinder tool. The project team reached out to several soil cell suppliers for product EPDs and these are still very much in development across the industry. GreenBlue Urban was able to provide an EPD for their RootSpace system which was inputted into Pathfinder as a representative number. The project team used the 600 series which represents a 600mm depth of soil volume. Only one tier of soil cells were included for each project to provide a comparable number across projects. As part of the soil cell assembly a 100mm depth of aggregate was assumed below the soil cell areas along with a layer of filter fabric.
- Perforated drain pipes are located within soil cell areas or where additional drainage is needed, for example below pet amenity surfacing
- Trench drains are considered but do not include the drainage piping and perforated drain pipes as the length and total area cannot be fully captured.
- Trench Drain covers in Pathfinder are included as they have a greater impact in terms of concrete and additional assemblies, area drain covers are not included since they have a minimal impact and drawings are usually representative in plans.
- Manhole covers are 70mm deep per OPSD 401.010

Others

- Flush curbs are to be included in laneway calculations and not counted in the private amenity calculations.
- Depth of precast concrete stairs is assumed to be 180mm from the average riser height
- ADA tactile pavers are representative of the City of Toronto standard TWSI and have a 90% rail and 10% truck transportation method. Most of these products are sourced from the US, and have a depth of 17mm at 610mm wide which is the standard dimension for the tactile pavers used in Toronto.

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