DS-05

SUSTAINABLE DESIGN STANDARD

Version 1.0

February 2021

THIS SECTION COVERS:

- Project Life-Cycle Analysis
- High Performance Buildings
- Building Water Management
- Storm Water Management
- Ecology
- Resilience
- Sustainability Plan & Reporting

TABLE OF CONTENTS

1 PREFACE

1.1 PURPOSE

This is the first edition of the *Metrolinx Sustainable Design Standard*. Questions and suggestions for improvement to this standard should be directed to the Sustainable Design team in the Design Division.

The purpose of the Sustainable Design Standard is to provide project delivery teams and designers consistent requirements and design best practices to apply to the delivery of capital and operationally cost efficient buildings, facilities and sites with high life-cycle sustainability performance. The standard emphasizes performance criteria, and provides a range of recommendations and options for designers to apply to meet the performance criteria. While having an emphasis on design requirements and best practices, the standard also covers reporting, and technical areas of sustainability.

Sustainability is a critical component of how Metrolinx plans, designs, builds and operates its transit facilities and is the core concept framing the vision of the Metrolinx 2041 Regional Transportation Plan. The Sustainable Design Standard implements the principles of sustainability throughout the design phase of projects and is an important tool in ensuring that Metrolinx's facilities are practical, durable and reliable. The Sustainable Design Standard is also flexible enough to be applied to a range of building facility and site types through various delivery and operating and maintenance models.

The Sustainable Design Standard is informed by global sustainable design best practices with an emphasis on Leadership in Energy and Environmental Design (**LEED)**, the Toronto Green Standard (**TGS**), the Envision Sustainable Infrastructure Framework, and the Canada Green Building Council (**CaGBC**) Zero Carbon Building standard. The Sustainable Design Standard applies to the full range of building types and delivery models.

The Sustainable Design Standard shall be used by project delivery teams in the Reference Concept Design and preparation of Project Agreements (**PAs**) and Metrolinx Asset Protection Plans (**MAPPs**), to set more specific sustainability requirements, particularly in refining the guidance and options of this standard.

1.2 OBJECTIVE

Cost-efficient buildings, facilities and sites with high life-cycle sustainability performance will be achieved through the following design objectives:

a) Enhance climate resiliency;

b) Effective sustainability data & metrics;

c) High performance buildings with low life-cycle energy use and emissions;

d) Support ecological systems;

e) Tools and support for sustainability informed design decisions;

f) Efficient operations and maintenance (**O & M**).

1.3 SCOPE

The Sustainable Design Standard identifies key sustainable design requirements, recommendations and options to be applied by consultants, designers, and contractors and shall be:

- Mandatory for the design of all new, expanded and reconstructed Metrolinx buildings and facilities;
- Mandatory for state of good repair capital infrastructure programs for Metrolinx sites and facilities; and
- Not applicable to On Corridor (**OnCorr**) rail and civil infrastructure outside station sites. At stations, the standard does not apply to rail and civil infrastructure within the active rail corridor.

This standard shall apply to all delivery methodologies, including third party deliveries, market-driven strategy deliveries, joint developments, alternate finance and procurement (**AFP**), construction management (**CM**), design build (**DB**), design bid build (**DBB**), and any other procurement types that involve design and/or construction of buildings and sites. The applicability matrix (Table 10 in section 11) provides a detailed breakdown of applicability of each standard section to the main project elements based on capital cost, Gross Floor Area (**GFA**), and site area. This standard applies to all Metrolinx delivered new building, site, building expansion, building reconstruction, and state of good repair (**SOGR**) projects subject to size and cost thresholds and project elements. Per Table 10, the following sub-sections do not apply to projects operated under GO Transit: 3.3.3 Mechanical Systems, 3.3.4 Electrical Systems, 4.1 Water Modelling, Metering and Monitoring, and 6.3 Light Pollution Reduction.

For the purpose of this standard, the term building refers to a fully enclosed structure that supports human occupation, including pedestrian bridges, tunnels, parking garages, fully enclosed shelters, and vertical pedestrian access. Buildings include any attached enclosed structures containing mechanical, electrical or other ancillary uses. Buildings include new stations, maintenance facilities and storage facilities. Buildings include above grade, at grade, and below grade. Applicability of the standard to temporary buildings shall be addressed on a case by case basis.

1.4 HOW TO USE THIS STANDARD

The approach for sustainable design needs to be an integral part of the design process, from concept to completion, with consideration to ongoing O & M of all Metrolinx facilities and infrastructure projects, apart from On Corridor rail and civil related works.

The standard is broken down into topic sections and sub-sections. Topics may have requirements, guidance and options. Guidance and options represent acceptable design approaches, subject to alignment with other Metrolinx standards; however, other design solutions may be acceptable subject to alignment with other requirements of this standard, and other project requirements. MAPPs and PAs shall reference this standard as a requirement and do not need to repeat requirements outlined within this standard. However, project delivery teams may elect to use MAPP or PA requirements to refine the applicability of standard sections/ sub-sections to reflect project opportunities and constraints. In particular, this standard covers many of the requirements of the CaGBC's Zero Carbon Building standard.

The design stages noted within this standard for various submissions are based on design submission schedules of typical projects; it is recognized that some projects will need to adapt the submission timing as appropriate to the project's submission schedule. For stations integrated into other buildings, this standard only applies to the portion of the building and site for which Metrolinx has obtained or intends to obtain full property rights.

1.5 LEGISLATIVE AND POLICY FRAMEWORK

The Sustainable Design Standard supports Metrolinx policies and strategies, in particular the 2041 Regional Transportation Plan, the Sustainability Strategy, and Climate Resiliency Strategy. The vision of the Metrolinx 2041 Regional Transportation Plan is that "The GTHA will have a sustainable transportation system that is aligned with land use, and supports healthy and complete communities. The system will provide safe, convenient and reliable connections, and support a high quality of life, a prosperous and competitive economy, and a protected environment."

It is required that each project be designed in accordance with the current version of all applicable standards, regulations, and codes to the approval of all authorities having jurisdiction. Where sustainability requirements vary between documents, the most stringent requirements shall apply. Furthermore, the Guidelines and Options available to a project in this standard may be constrained by applicable standards, regulations and codes. Applicable legislation includes, but is not limited to, the latest versions of:

- Ontario Building Code
- National Energy Code for Buildings
- National Building Code of Canada
- Applicable standards, regulations, and codes to the approval of all authorities having jurisdiction in effect at the time of a project agreement.

1.6 KEY CONCEPTS

1.6.1 SUSTAINABILITY

The Sustainable Design Standard implements the principles of sustainability throughout the design phase of projects and is an important tool in ensuring that Metrolinx's facilities are practical, durable and reliable. Metrolinx has adopted the three tenets (principles) of sustainable development as outlined by the Brundtland Commission in 1987:

a) *Meet the needs of the present without compromising the ability to meet future needs;*

b) *Consider the interrelationships between the natural* *environment, people living in it and the economy; and*

c) *Rely on multiple perspectives to understand the complexity of issues and garner the support needed to implement initiatives to advance sustainability.*

Traditional practice generally emphasizes capital costs and operational environmental impacts. The Sustainable Design Standards takes a life-cycle costing and environmental impact approach to sustainability. The determinants of sustainability performance for this standard include climate resiliency, natural resource use, energy and emissions intensity, and ecosystem health. These determinants function in a complex system with other social, economic and environmental sustainability factors.

1.6.2 CLIMATE ADAPTATION

The 2018 Metrolinx Climate Adaptation Strategy states that adaptation is "the ability of Metrolinx, its infrastructure assets, and the component parts of its regional transit system to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions."

1.6.3 CLIMATE CHANGE MITIGATION

Climate change mitigation covers actions that eliminate or reduce emissions of greenhouse gases or that create, protect or enhance carbon sinks.

1.6.4 CARBON BALANCE

Net emissions represent the life-cycle carbon balance of a project. Net emissions include embodied carbon emissions plus operational emissions with adjustments based on off-sets per Figure 1. Past projects have focused on operational carbon, but as buildings become more energy efficient the relative significance of embodied carbon grows. Per Figure 1, embodied carbon emissions includes upfront, use and end of life emissions and are 'locked-in' at the time of construction.

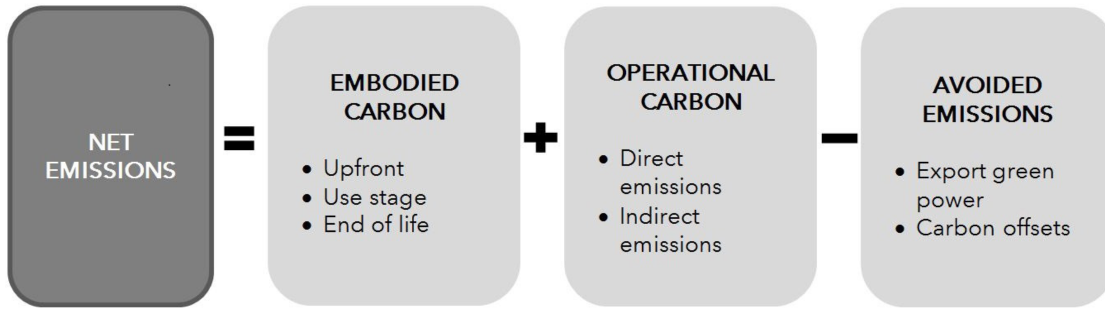

Figure 1: Carbon Balance

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City of Toronto. *Wet Weather Flow Management Guidelines, November 2006*. (https://www.toronto.ca/wp-content/uploads/2017/11/9191-wwfm-guidelines-2006-AODA.pdf)

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Where sustainability requirements vary between reference documents, the most stringent requirements providing the most sustainable solution shall apply. In addition, all variances in the requirements between reference documents and their interpretation shall be identified and submitted to Metrolinx for review and approval. Note that the design shall follow the most up-to-date documents in effect at the time of project agreement finalization.

2 PRE PROJECT LIFE-CYCLE ANALYSIS

Pre project life-cycle analysis consists of two separate, but related, sub-sections: life-cycle cost and life-cycle assessment. Life-cycle cost focuses on costs, where life-cycle assessment is the analysis of environmental impacts through a life-cycle lens with a focus on embodied carbon.

2.1 LIFE-CYCLE COST

2.1.1 OBJECTIVES

The objective of this section is to support sustainable design decision-making through estimating the life-cycle costs (**LCC**), comprising:

- Construction;
- Maintenance;
- Operations;
- Occupancy; and
- End of life (decommissioning and replacement) related costs.

LCC is a component of Whole Life Costs (**WLC**) – WLC includes income, externalities, and non-construction costs, which are items which are beyond the scope of this section (Figure 2).

The purpose of an LCC process is to acknowledge and incorporate a long-term cost analysis of the financial impact of alternatives during project definition and design development. The O & M phase of a building can contribute between 50% and 80% of the total LCC (Figure 3). An understanding of the life-cycle costs of infrastructure can support sustainable design options through better understanding the trade-offs of upfront capital costs with O & M costs. Often, sustainable design options increase initial capital costs with long-term O & M cost savings. In that sense, the true value of sustainable design solutions only becomes apparent over time, and this is a key factor for long-term owners of built infrastructure. Using the process guidelines set out in this section, Metrolinx also intends to develop a database of life-cycle costs to inform future decisions.

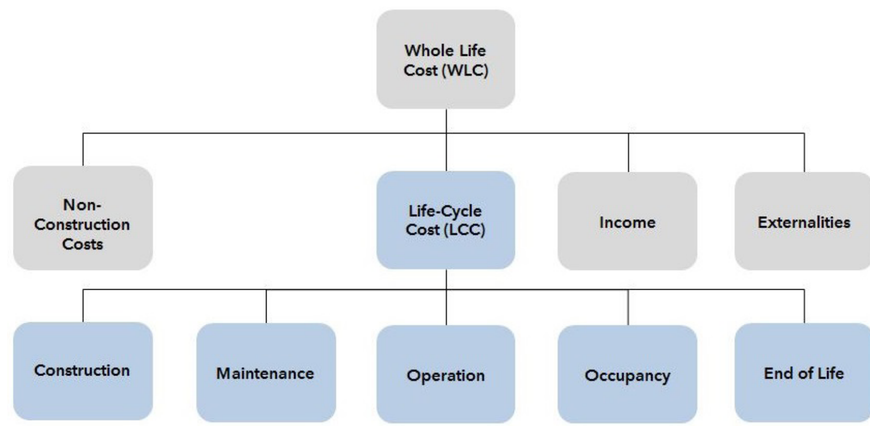


Figure 2: Whole Life Cost Breakdown

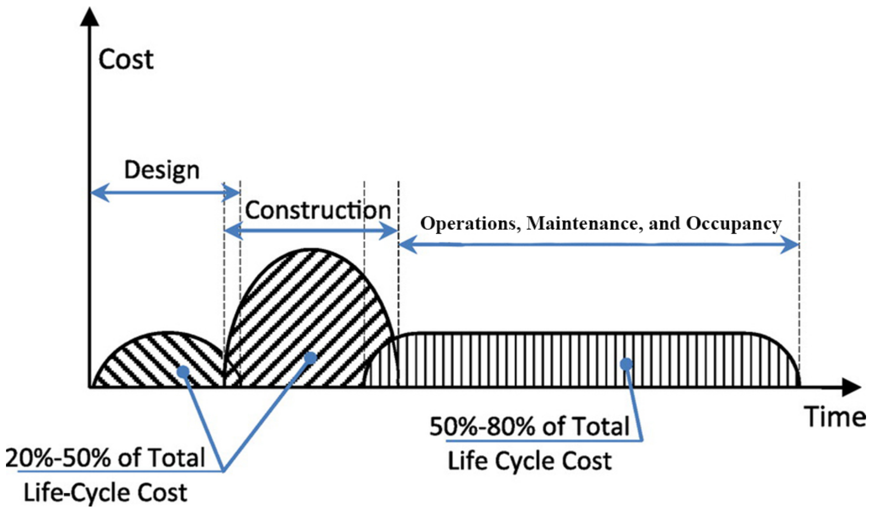


Figure 3: Life-Cycle Cost by Phase

2.1.2 REQUIREMENTS

All projects with a capital cost of more than $30 Million, shall produce a life-cycle cost estimate that:

a) Is compatible with the latest version of ISO 15686-5;

b) Defines the reference building design (a 'base case' scenario) and the proposed design;

c) Follows the form and intent of the life-cycle cost template set out as an example in Table 11 of Appendix B;

d) Allows for all related O & M input costs. All costs and estimates to exclude Harmonized Sales Tax. Cost estimates shall include details on operations, predictive and preventative maintenance, and corrective maintenance;

e) Incorporates a competent estimate of Initial Capital Cost, with the level of estimate detail dependent on the quality of the input design information;

f) Includes a competent estimate of the end-of-life related costs, together with assumptions and estimate detail (costs related to the renewal/replacement of the asset);

g) Properly offsets credits and/or savings against relevant expenditures at Initial Capital Cost and over the evaluation timeline;

h) Defines the investment criteria (Present Value (**PV**) of life-cycle costs, Net Present Value (**NPV**), payback period, etc). Note that generally the PV of life-cycle costs will be the most appropriate; and

i) Accounts for the following factors:

- Study/ Evaluation Period – the timeline of the analysis will be set by Metrolinx in each case, taking into consideration the typical design life of the asset;
- Escalation rates – to be defined and set in each case. More than one escalation rate may be relevant; for example, different escalation rates may be applicable to long-term energy costs, and construction repair/replacement activities;
- Discount rate - to be per Metrolinx Business Case

Guidance, unless otherwise set by Metrolinx;

- Sensitivity analysis with the parameters per Metrolinx Business Case Guidance; and
- Costs shall be provided annually for each component.

2.1.3 OPTIONS

All projects with a capital cost of more than $30 Million may consider:

a) Model the LCC analysis such that the outcome is a long-term measure of value of a sustainable design alternative over a 'base case' or conventional design and/or technology;

b) Utilize NRCan Lifecycle equations for custom product and materials, or similar computing tools and applications relevant to the purpose;

c) Compare the life-cycle cost of sustainable design options during the preliminary design phase of a project;

d) Align with the latest version of the Global Consistency in Presenting Construction and other Life-Cycle Costs standard by the International Construction Management Standards Coalition; and

e) Update the design life of components per section 7: Predicted Service Life of Components and Assemblies of CSA 478: Guideline on Durability in Buildings.

2.1.4 REPORTING DIRECTION

Metrolinx develops infrastructure asset types, including, but not limited to:

- Pavement
- Stations and Terminals
- Bridges and Overpasses
- Tunnels
- Shelters
- Maintenance and Storage Facilities
- Sub Stations
- Layover facilities
- Other civil infrastructure elements (culverts, etc.)

At the commencement of the LCC exercise, the LCC Consultant and Metrolinx will discuss and agree on an estimate of the asset design life, and the evaluation/ study period (expressed as the number of years).

The LCC Consultant shall develop a logical format by component, to record the LCC cost data. An example of the anticipated format for building projects is set out in Table 11 of Appendix B.

2.2 LIFE-CYCLE ASSESSMENT (EMBODIED CARBON)

2.2.1 OBJECTIVES

Metrolinx has committed to reducing its energy use and emissions. Greenhouse gas **(GHG)** emissions globally are driving climate change. Through this section Metrolinx will support industry knowledge of life-cycle assessment **(LCA)** techniques, particularly in global warming potential, and gain project level LCA data to facilitate improved future decision making. Global warming potential (GWP) is expressed in carbon dioxide equivalent (**CO_2e**).

Projects should consider using LCA to support project decisions. While reducing carbon emissions is possible at all stages of project delivery, opportunities are greater and more cost-efficient in earlier stages (Figure 4).

The requirements of this section contribute towards the requirements of credit: Building Life-Cycle Impact Reduction in BD+C for **LEED** version 4. Note that there are various approaches to calculating the embodied carbon of a project.

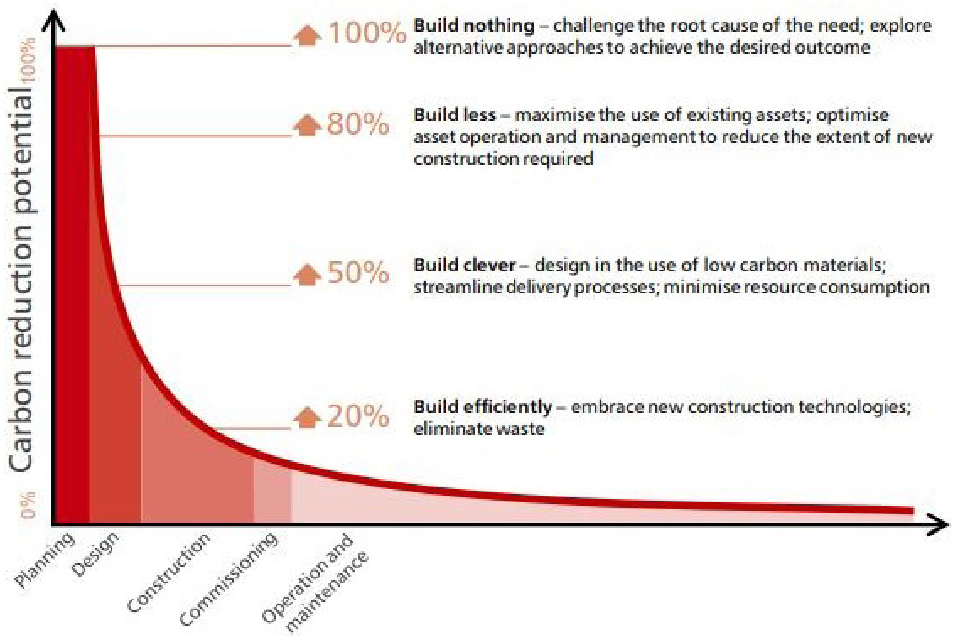


Figure 4: Carbon Reduction Curve (Source: Green Construction Board)

2.2.2 REQUIREMENTS

All building projects (new, reconstruction and expansion) and roadway and pavement construction with a capital cost of more than $30 Million shall:

a) Develop a life-cycle assessment (or **LCA**) for embodied carbon that:

1. For buildings, bridge structures, underpasses and platforms, use the Athena Impact Estimator for Buildings Software (https://calculatelca.com/software/impact-estimator/), One-Click LCA (www.oneclicklca.com), Tally (choosetally.com) or equivalent with prior approval from Metrolinx. Any software used shall use analysis specific to the GTHA; and

2. For roadways and parking lots, use the Athena Pavement LCA software (https://calculatelca.com/software/pavement-lca/) or equivalent with prior approval from Metrolinx.

b) Provide CO_2e emissions by project life-cycle stages (product, construction, operations, and end-of-life), with summary and detailed break-down by components and materials;

c) Provide Metrolinx the Bill of Materials used for the LCA;

d) Include the social cost of carbon used by Environment and Climate Change Canada as part of the analysis; and

e) Provide a report on the embodied carbon analysis, including:

1. Boundary of assessment: this section will describe required scope and limits of the assessment. In the context of LCA, specific elements could include the timescale of the assessment, what particular construction materials and the types of activities are considered, etc;

2. Greenhouse gases considered: this section describes the types of GHGs considered in the assessment. Typically, carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O); hydrofluorocarbons (HFCs); perfluorocarbons (PFCs); sulphur hexafluoride (SF_6); and nitrogen trifluoride (NF_3) are considered in an assessment. These will be converted to tonnes CO_2 equivalent for the purpose of the calculations;

3. Emissions Scope: this section describes the required scope of emissions considered in the analysis of the Project (Scope 1 covers direct emissions from owned or controlled sources including construction and operation of infrastructure. Scope 2 covers indirect emissions from the generation of purchased electricity, steam, heating and cooling consumed by the infrastructure owner. Scope 3 includes all other indirect emissions that occur in the project's value chain including production and transportation of materials used in construction and operations);

4. Data collection and calculation method: this section provides information regarding the formulae and data used in the analysis including a clear list of assumptions and inputs into the LCA calculation

software such as the bill of materials; and

5. Exclusions: this section describes the information that was intentionally omitted from the assessment, rationale or justification for exclusions to be provided.

2.2.3 GUIDANCE

All building projects (new, reconstruction and expansion) and roadway and pavement construction with a capital cost of more than $30 Million should report additional LCA metrics.

2.2.4 OPTIONS

All building projects (new, reconstruction and expansion) and roadway and pavement construction may:

a) Calculate the CO_2e LCA for additional project components not covered by the above software (such as landscaping). Calculations should use techniques defined in PAS 2080 or equivalent; and

b) Compare the CO_2e LCA of different design options during the design development phase of a project. The same methodology should be used for each option (i.e. a comparison cannot be made between options analysed using different software). Note that at a minimum the following metrics should be the same in order to conduct a comparison of design options for a building:

- Location;
- Building Type (type of occupancy);
- Building Life Expectancy (Years);
- Building Height (m); and
- Gross floor area (m^2).

2.2.5 REPORTING DIRECTION

Table 1 defines a suggested list of materials with Global Warming Potential equivalencies to be calculated as part of the LCA to be provided to Metrolinx if a non-software approach is used or where the software can readily provide these equivalencies. Table 2 provides an example of a summary table that could be produced through the Athena Impact Estimator for Buildings Software.

Table 1: Life-Cycle Assumptions Included in the LCA Analysis

Activity	Material	Global Warming Potential
Construction Materials	Concrete	CO_2e Per kg or per tonne (Kg CO eq)
	Concrete w/ reinforcement	CO_2e Per kg
	Steel	CO_2e Per kg
	Wood	CO_2e Per kg
	Aggregate/fill	CO_2e Per kg
	Glass	CO_2e Per kg
	Aluminum	CO_2e Per kg
Transport	Input and export from site of materials	CO_2e Per tonne transported per km driven
	Construction equipment	CO_2e Per L of diesel or gasoline.
Energy	Natural Gas	CO_2e Per kWh
	Hydroelectric	CO_2e Per kWh
	Renewables Generation on Site	CO_2e Per kWh
Water	Potable Water (site operations only)	CO_2e Per L
Other activities as defined by Metrolinx		

Table 2: Sample Athena Summary Table by Life-Cycle Stages

		Product (A1 to A3)	Construction Process (A4 & A5)	Use (B2, B4 & B6)	End of Life (C1 to C4)	Beyond Building Life (D)	Total Effect	
Summary Measure	**Unit**	**Total**	**Total**	**Total**	**Total**	**Total**	**A to C**	**A to D**
Global Warming Potential	kg CO_2 eq	14006.22	1703.54	8138.05	905.89	-2332.93	24753.69	22420.76
Acidification Potential	kg SO_2 eq	61.48	15.58	30.30	11.53	1.62	118.90	120.51
HH Particulate	kg PM 2.5 eq	28.08	1.17	29.51	0.56	0.71	59.33	60.04
Eutrophication Potential	kg N eq	11.98	1.42	9.06	0.72	0.08	23.19	23.27
Ozone Depletion Potential	kg CFC-11 eq	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Smog Potential	kg O_3 eq	1021.31	462.33	244.55	378.39	16.36	2106.58	2122.94
Total Primary Energy	MJ	174061.08	20816.27	125093.67	13401.03	3239.68	333372.05	336611.73
Non-Renewable Energy	MJ	141182.42	20259.84	113776.95	13395.39	3239.68	288614.59	291854.27
Fossil Fuel Consumption	MJ	117622.58	19669.42	93645.67	13374.60	6499.78	244312.28	250812.06

2.3 MATERIAL LIFE-CYCLE IMPACTS

2.3.1 OBJECTIVES

The objectives of this section are to support the life-cycle analysis through requirements and strategies to reduce the embodied and operational environmental footprint of materials. All requirements, guidance and options are subject to ensuring high asset quality and durability.

The principles are to first reduce materials usage, second to use materials with lower embodied environmental impacts and high recyclability/re-use, and third to facilitate material recycle and reuse through operations.

2.3.2 REQUIREMENTS

All projects shall:

a) Achieve a minimum 75% construction waste diversion by volume, excluding aggregate, fill and hazardous materials;

b) Use optimal and compact building form to reduce overall building materials used; and

c) Use low carbon cement or Portland-limestone Cement for concrete or mortar which has a higher proportion of supplementary cementitious materials **(SCM)** (e.g. slag, fly ash, etc.) as a partial substitute for Portland cement. The use of SCM, and also reduces the embodied carbon.

All new buildings that will not be operated under GO Transit shall:

d) Ensure that the design provides appropriate space allocated to the collection and handling of all anticipated wastes during the operation of the facility, with space allocations based on functional area of the building; at a minimum, garbage enclosures must be large enough to conceal two 6-yard bins;

e) The Consultant shall verify garbage and recycling bin sizing with station, local municipality and/or service provider to validate garbage enclosure dimensions prior to design; and

f) Provide appropriate space for sorting and monitoring of waste. Where organic/compostable waste management is required, provide a secure, animal-resistant collection area for organic/compostable waste.

2.3.3 GUIDANCE

All projects should:

a) Use products, where available, from manufacturers who have validated triple bottom line (environmental, economical, and social) life-cycle information relevant to the product through independent, consensus-based, third party certifications. The products must have earned and still maintain certification under the scheme.

2.3.4 OPTIONS

Projects may consider:

a) Decreasing the volume and/or weight of the structure, which has considerable potential for reducing embodied carbon. Replacing solid concrete with cellular concrete and hollow core concrete can significantly reduce structure's weight and embodied emissions;

b) Replacing concrete with wood structure reduces the building weight, and therefore the amount of foundation materials needed which result less carbon emissions. Wood also has a lower embodied carbon, and sequesters carbon, as compared to concrete, and metal materials;

c) Using reusable material as raw material where feasible. Hazardous materials shall not be reused. For example crushed concrete can be used as aggregates in new concrete, and Green Label Plus or recycled material can be used in carpet;

d) Using prefabricated elements such as façade panels and glazing that reduce construction waste and construction time and can be reused;

e) Incorporating prefabrication, factory assembly, panelized or modular volumetric construction where feasible;

f) Incorporating high-quality upcycled materials from waste can reduce emissions, if the upcycling facility has low impacts; and

g) Using thermal insulation made of glass, resistant to aging, pest-resistant and non-flammable. Recycled glass is the ideal insulation material. In the form of foam glass ballast, it is easy to handle, versatile in use and a low-cost alternative to conventional building materials. It can therefore be used on the one hand under floor slabs, while on the other hand it is suitable for the insulation of roofs and ceiling structures.

3 HIGH PERFORMANCE BUILDINGS

3.1 BUILDING ENERGY AND CARBON PERFORMANCE TARGETS

3.1.1 OBJECTIVES

This section provides base requirements and guidance for higher levels of building performance. Higher performing buildings are highly energy efficient in their building envelope, mechanical systems and electrical systems, with lower operational GHG emissions. Guidance is provided for performance with near zero operational GHG emissions, and for a transition from natural gas to electrical systems in the future. In Ontario, zero emission buildings have energy efficient, fully electrified mechanical systems, with energy fully off-set on or off-site with renewable power sources.

3.1.2 REQUIREMENTS

All new buildings with a GFA of actively heated and cooled spaces greater than 100m^2 shall:

a) Meet NECB 2015 Climate Zone 7's prescriptive path requirements for the building envelope;

b) Achieve a Thermal Energy Demand Intensity (**TEDI**) of ≤ 32 kWh/m^2/year;

c) Achieve a minimum 25% energy improvement over a reference building per the corresponding version of ASHRAE 90.1 or NECB where the building is pursuing **LEED**;

d) Achieve a minimum 25% energy improvement over a reference building per ASHRAE 90.1 2013 or NECB 2015 for other buildings;

For all new buildings with only passive heating and cooling;

e) The energy performance shall meet ASHRAE 90.1 2013 or NECB 2015 where the building is pursuing a Building Permit only; and

f) Where the building is to meet OBC SB-10, the energy performance of the design shall meet the requirement of ASHRAE 90.1 2013 or NECB 2015, and additional requirements introduced through OBC SB-10 2017 Division 3 Chapter 2.

3.1.3 OPTIONS

New building projects with a GFA of actively heated and cooled spaces greater than 100m^2 may:

a) Use Energy Star Portfolio Manager Site Canadian National Median Site Energy Use Intensity (**EUI**) in (GJ/m^2) as a benchmark for the new building design and that the site EUI from the energy model should be less than the National Median Site EUI. Refine design options to achieve EUI benchmark/target;

b) Achieve CaGBC Zero Carbon Building Standard version 2;

c) Achieve Toronto Green Standard version 3, tiers 2, 3 or 4 with credit applicability subject to Metrolinx review; and

d) Achieve **LEED** certification at Gold with a focus on energy efficiency related credits.

3.2 ENERGY SIMULATIONS AND MODELING

3.2.1 OBJECTIVES

The objectives of this section are to support the integrated design of energy efficient buildings and to develop a comprehensive understanding of the anticipated energy consumption and GHG emissions of designs for new Metrolinx buildings.

As per the latest Ontario Building Code (**OBC**), new construction buildings need to report the following building performance information at a minimum: energy efficiency level, GHG emission level, and peak electric demand. Therefore, energy modeling is a critical tool for building design to ensure energy performance information is determined with good engineering practice. Additionally, energy modeling supports the compliance process for energy efficiency standards Metrolinx uses such as: TGS, LEED, and the CaGBC Zero Carbon Building Standard. This section also aims to build a database of energy models and energy consumption design parameters for energy and GHG emission benchmarking to enable Metrolinx to make better decisions around procurement of all assets.

3.2.2 REQUIREMENTS

All new buildings with a GFA of actively heated and cooled spaces greater than 100m^2 shall:

a) Produce a preliminary energy model (a simplified box type is acceptable) at no later than 30% design (development design to schematic design stage) that:

1. Helps the design team and Metrolinx explore the energy consequences of design options;
2. Provides an early estimate of energy performance to inform the design process;
3. Follows the standardized methodology provided in ASHRAE Standard 209-2018, "Energy Simulation Aided Design for Buildings except Low Rise Residential Buildings"; and
4. Is updated to reflect design details as the design is being refined further throughout design; and
5. Is summarized in a report submitted at no later than 30% design.

b) Produce a full-building simulation model that:

1. Reports the end-use breakdown to inform the design team of major energy related matters;
2. Reports the building's Energy Use Intensity (**EUI**) in kWh/m^2/year, Thermal Energy Demand Intensity (**TEDI**) in kWh/m^2/year, and Greenhouse Gas Intensity (**GHGI**) in kgCO_2/m^2/year, Peak Electricity Demand (kW), and the generated renewable energy (kWh/year) along with Solar Photo-Voltaic and/or Solar Thermal design analysis when it is applicable;
3. Is made available to Metrolinx upon the substantial completion of the project; and
4. Is summarized in a report submitted to Metrolinx

upon substantial completion of the project.

c) Produce a preliminary Energy model and full-building simulation model that:

1. Uses energy model calculations performed using values of climate data (CWEC file is preferred), including temperature, humidity, and insolation, that are representative of 10 years average. For urban regions where the weather data are not available, the energy modeling shall be performed using available weather data that best represents the climate at the building site;

2. Incorporates operation schedules relating to the presence of occupants, where relevant (with occupant counts provided by Metrolinx) and of loads due to the operation of lighting, plugs, heating, cooling, and service water heating systems representative of the building type or space function. The predefined schedules from ASHRAE 90.1 and NECB can be selected. Occupant counts are not relevant to stations;

3. Where snow melt systems using natural gas are proposed, compares metrics with and without a snow melt system;

4. Is the basis of design option life-cycle cost. The utility rates, carbon tax, and GHG emission factors to be used in the calculation are to be provided by Metrolinx; and

5. Uses an hour-by-hour energy simulation software. See section 3.2.3(b) for a list of recommended software.

d) Produce an As-Constructed Stage Energy Report that:

1. Reflects the building's final design including any changes made during the construction phase that is submitted after occupancy begins and all necessary shop drawings and as-built drawings are issued; and

2. Produces anticipated load demands to be validated through sub-metering at time of commissioning;

All other new buildings to meet OBC SB-10 shall:

e) Produce an energy model and summary report proving the energy performance of the design meets the requirement of ASHRAE 90.1 2013 or NECB 2015, and additional requirements introduced through OBC SB-10.

3.2.3 GUIDANCE

All new building projects should:

a) Use the ASHRAE 90.1 and NECB pre-defined operation schedules, Lighting Power Density (**LPD**) and plug loads, and occupant densities in the preliminary energy model;

b) Use the following preferred energy simulation software: IESVE, DOE-2, EnergyPlus, Hourly Analysis Program (**HAP**), or equivalent that conform to ASHRAE 140

"Evaluation of Building Energy Analysis Computer Programs";

c) Perform energy modelling for any passive design strategies to estimate and verify the impacts from the passive design strategies. Note that the calculated annual GHG emission, peak electric demand might still need to be reported as per OBC SB-10;

d) Follow CaGBC's supplemental document, Guidance for Energy Modelling Compliance Documentation in LEED Canada; and

e) Follow Energy Efficiency Report Submission & Modelling Guidelines for TGS Version 3.

3.2.4 OPTIONS

Post-construction energy modeling may:

a) Evaluate design options that facilitate a future transition away from natural gas systems to electric, including solar PV, with minimal impact to the buildings energy systems. The evaluations should be supported with a GHG emissions comparison between a NG fired heating system option and a fully electrified heating system option;

b) Update energy models to reflect any changes and modifications that are made to the facility, calibrated with the measured energy data on an annual basis for the duration of the Contract Operate and Maintain period; and

c) Run the energy model with RETScreen Clean Energy Project Analysis Software, by Natural Resources Canada, to allow for performance analysis with sub-meter energy data after site is commissioned (and GHG analysis).

3.3 ENERGY EFFICIENT DESIGNS

3.3.1 OBJECTIVES

The objectives of this section are to reduce overall energy consumption and GHG emissions of new buildings by enhancing the efficiency of mechanical equipment, providing cleaner source of energy for heating and cooling of building and by minimizing the heat gain/loss through building envelope and to enhance the thermal resilience of stations in the event of a power outage.

3.3.2 BUILDING ENVELOPE

3.3.2.1 REQUIREMENTS

All new buildings with a GFA of actively heated and cooled spaces greater than $100m^2$ shall:

a) Minimize **thermal bridges**, such as thermally unbroken slab edges and other features in the building façade;

b) Perform an airtightness test of the actively heated and cooled space after construction completion per the requirements of ASHRAE 90.1 - 2016 section 5.4.3.1.3(a). The building shall achieve a normalized maximum air leakage rate of 2.0 $L/s\text{-}m^2$ at 75 Pa in accordance with

ASTM E779 or ASTM E1827 by an independent third party. The airtight line shall be continuous even when formed of different materials and it shall be joined up, even where there are penetrations. A summary report shall be submitted to Metrolinx, summarizing the method undertaken, test results, and corrective actions undertaken or planned;

Subject to alignment with other applicable Design Standards, all new buildings with a GFA of actively heated and cooled spaces less than $100m^2$ shall:

c) Optimize glazing placement, ratios and building orientation to increase solar gains in the winter months while mitigating solar gain in the summer months; in particular, shading devices or other design strategies shall be provided over south facing glazing to lessen incoming solar gains in the summer months while still allowing solar gains in the winter months; and

d) Specify exterior glazing to be insulating and Low E glass.

3.3.2.2 GUIDANCE

Subject to alignment with other applicable Design Standards, all building projects (new, reconstruction and expansion) should:

a) Optimize building orientation and site placement in the preliminary design stage to reduce the **TEDI**. Provide a study of winter solar radiation gain, minimum energy loss etc. Building orientations and characteristics of the site have a huge influence to building over time. It is recognized that site constraints and orientation to fixed assets such as rail corridors may limit options;

b) Design a compact building form that minimizes complicated junctions and variations in the façade. This will provide a more efficient area to volume ratio and will minimize thermal bridging through the building envelope;

c) Optimize glazing placement during the building orientation design. Optimal design should increase solar gains in the winter months while mitigating solar gain in the summer months; in particular, shading devices or other design strategies should be provided over south facing glazing to lessen incoming solar gains in the summer months while still allowing solar gains in the winter months;

d) Provide passive ventilation through the appropriate placement of windows and operable windows to use incoming fresh air to move warm and stale air out of a building;

e) Optimize natural light from the sun (daylighting) to reduce the need for artificial, electric lighting within buildings. Natural light can dramatically reduce a building's EUI; and

f) Optimize the quantity of glazing seams and arrangement to achieve a low **TEDI**. This can significantly influence the impact of thermal bridging to the wall interface. Typically, a balance of both glazing area and shape should be considered as illustrated in Figure 5 and Table 3. Figure 5 and Table 3 illustrate four generic glazing layouts that lead to different outcomes for thermal transmittance due to the quantity of the window to wall interface.

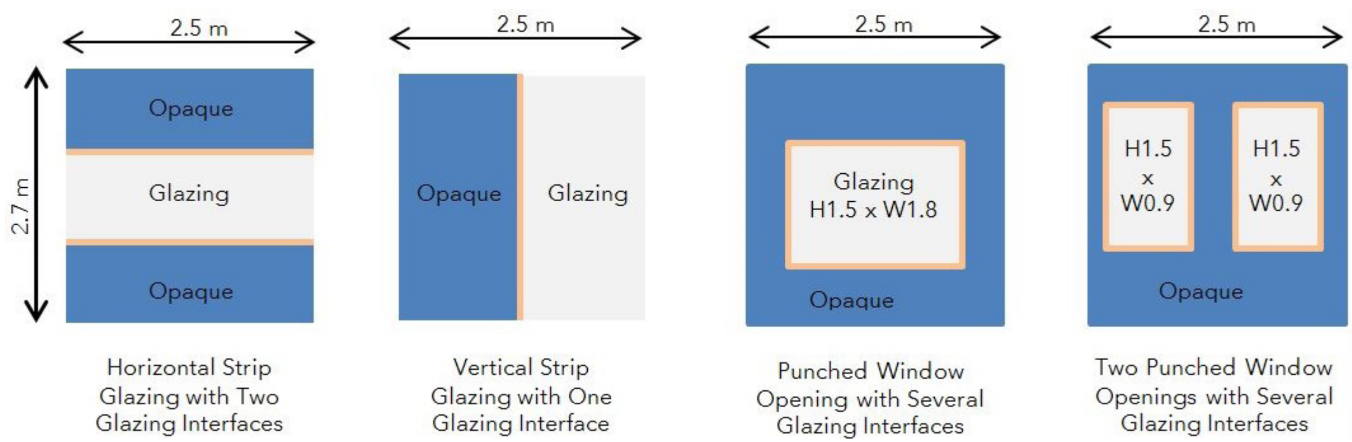


Figure 5: Glazing Layouts

Table 3: Example Glazing Layout Calculations

	Horizontal Strip Glazing	Vertical Strip Glazing	Punched Window Opening	Two Punched Window Openings
Interface Length (m)	5	2.7	6.6	9.6
U-Value (W/m²K)	0.566	0.467	0.617	0.733
Effective R-Value	10.2	12.2	9.2	7.8

3.3.2.3 OPTIONS

Subject to alignment with other applicable Design Standards, all building projects (new, reconstruction and expansion) may:

a) Use Light Shelves to help to gather and reflect incoming solar radiation and help to light interior spaces without overheating. A light shelf is a horizontal surface that reflects daylight into a building space. The design of light shelves shall facilitate window maintenance.

b) Use solar control dynamic glass to improve indoor comfort and lower energy consumption. It also eliminates the need for traditional blinds and shading, saving material and maintenance cost;

c) Use Intermediate Building Elements. Understanding that the appropriate building orientation may not always be in line with the site, specifically tracks, the design should introduce building elements such as canopies, etc., to tie in the two together, these elements shall allow for the building to maintain its required orientation while architecturally connecting it to the tracks or other binding site features; and

d) Use solar tube lighting, also known as a sun tube, sun tunnel, light tube, or tubular skylight.

3.3.3 MECHANICAL SYSTEMS

3.3.3.1 GUIDANCE

Mechanical systems shall be designed to achieve efficiency targets per the requirements of section 3.1. For GO branded buildings, mechanical requirements are specified in other standards. To improve energy efficiency, particularly the EUI, it is recommended that all new buildings that will not be operated under GO Transit should specify:

a) Gas fired equipment such as boilers, domestic hot water tanks, air handling units, make-up air units etc. be a minimum energy efficiency of 97%. Condensing boilers are not recommended where connected to a glycol snow melt system;

b) High efficiency rooftop units with economizers;

c) Tankless domestic water heater be specified instead of tank heaters;

d) Motors for mechanical equipment such as pumps and fans be ‘Premium Efficiency Motors’;

e) Variable frequency drive for all motors above 3 HP (2.2 kW) be complete;

f) Part-load performance of equipment be considered during selection of mechanical equipment as it is a critical consideration for HVAC sizing. Most HVAC equipment only operates at their rated, peak efficiency for 1% to 2.5% of the time. Select equipment that can operate efficiently at part-load;

g) Energy recovery units with minimum effectiveness of 60% for mechanical ventilation of spaces;

h) Ductwork connected to mechanical equipment be designed to reduce the static pressure of the system. Follow SMACNA standards for best practices for ductwork construction;

i) VAV units for air terminals wherever possible to reduce the energy consumption; and

j) Air curtains for overhead doors in the maintenance facilities and for the high- traffic doors in the station buildings. Electric heated air curtains should be considered for doors separating the conditioned spaces with outdoors.

3.3.3.2 OPTIONS

All new buildings that will not be operated under GO Transit targeting higher level of performance (EUI and GHGI) may specify:

a) Air Source Heat Pumps in lieu of natural gas heating equipment. Where air source heat pumps are proposed it is recommended that:

   1. Air source heat pumps be variable refrigerant flow type heat pumps; and

   2. A supplementary heating source be included to supplement the air source heat pump when the outdoor temperature is below the frost temp of the unit. For a lower **GHGI**, the supplementary heating source should use an electrical system.

b) Ground source heat pumps. Where ground source heat pumps are proposed, it is recommended that:

   1. A feasibility study be conducted prior to propose geothermal energy for space heating and for domestic hot water heating;

   2. The system provide heating and chilled water in various mechanical equipment such as hydronic air handling units, rooftop units and fan coil units etc;

   3. Charging of geothermal bore may be required to maintain energy levels in the bore and to avoid freezing of the bores. If feasible, charging of the bore should be done through a renewable source of energy such as solar PV to achieve a lower GHGI. Additional solar panels would be required to charge the bore; and

   4. During winter, when the bore temperature drops below freezing temperature, the heat pump will be ineffective and will not be operational. At that time, a supplementary boiler will be required to provide heating water for space heating.

c) Air to water heat pumps. Where air to water heat pumps are proposed it is recommended that:

   1. The system provides heating and chilled water in hydronic air handling units, rooftop units and fan coil units.

2. Additional source of heating such as boiler be included when the outdoor air temperature drops below frost temperature of the heat pump.

d) Solar Walls to pre-heat ventilation, subject to applicable Design Standards. Solar wall can be used to pre-heat the outside ventilation air. The perforated solar panels installed on south wall will allow fresh air to enter a wall cavity behind the metal collector where the HVAC system is connected to pre-heat large volumes of ventilation air to the building (Figure 6). Related alternative technologies include Trombe walls or air shafts. However, for south exterior facades where there is no need for glazing, using solar thermal walls is suggested;

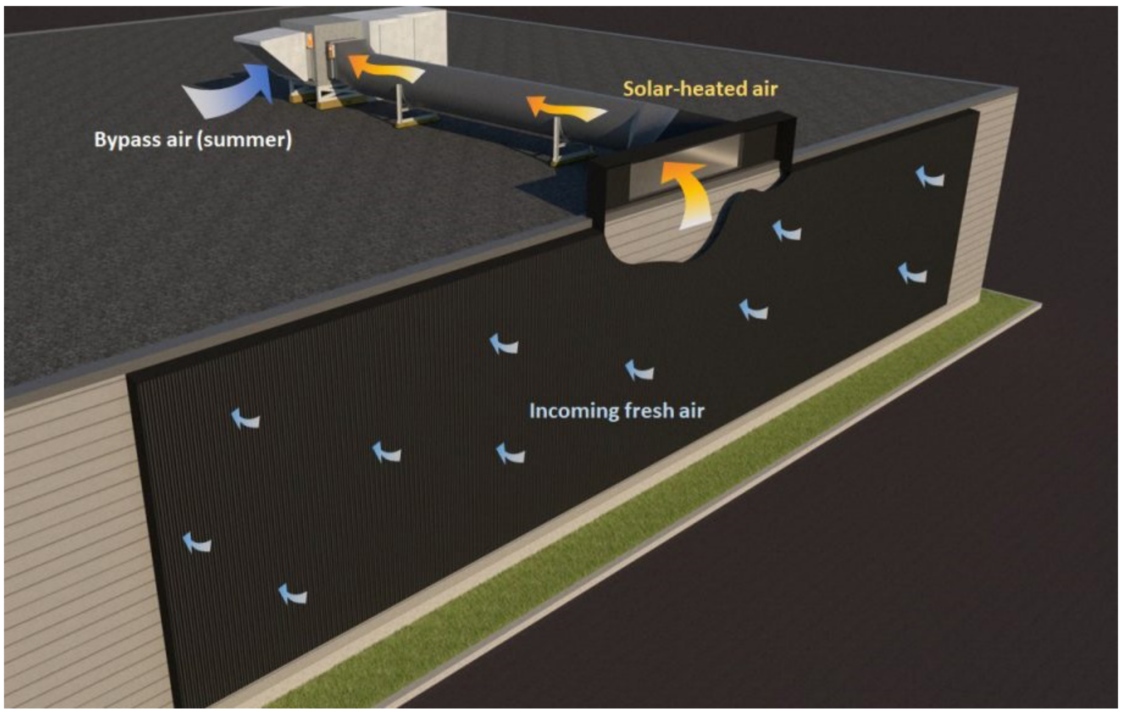


Figure 6: Solar Wall

e) Double-skin façades (**DSF**), subject to applicable Design Standards. The double-skin façade, or DSF, is an envelope construction composed of two transparent ''skins'' that are separated by an air corridor. It integrates passive design strategies, such as natural ventilation, daylighting, and solar energy. The DSF is a hybrid which uses some mechanical energy in addition to the natural and renewable energy resources. A DSF system can be created over an entire façade or just a portion of it and it is applicable to all kinds of buildings;

f) Solar Thermal systems for hydronic heating and for domestic hot water heating. Solar thermal system can be used for domestic water heating and space heating. The efficiency and performance of solar water heating systems depend on a site's solar energy resources. The amount of solar energy available for heating water varies by geographical location, cloud cover, site latitude, season of year, solar collector tilt, orientation to path of sun, shading and collector placement within building cluster.

The main mechanical components required for the solar hot water thermal system are:

- Collector field including field piping and support structure
- Heat transfer fluid, usually 40% propylene glycol
- Pumps for solar loop and other loops (hydronic space heating and/or domestic hot water heating.
- Heat exchangers to transfer heat from one loop to another.

Solar thermal system does not usually act as the main heat source, an auxiliary (back-up) heating source is needed, typically an electric or high efficiency condensing boiler (Figure 7); and

g) Earth tubes for pre-conditioning of make-up air.

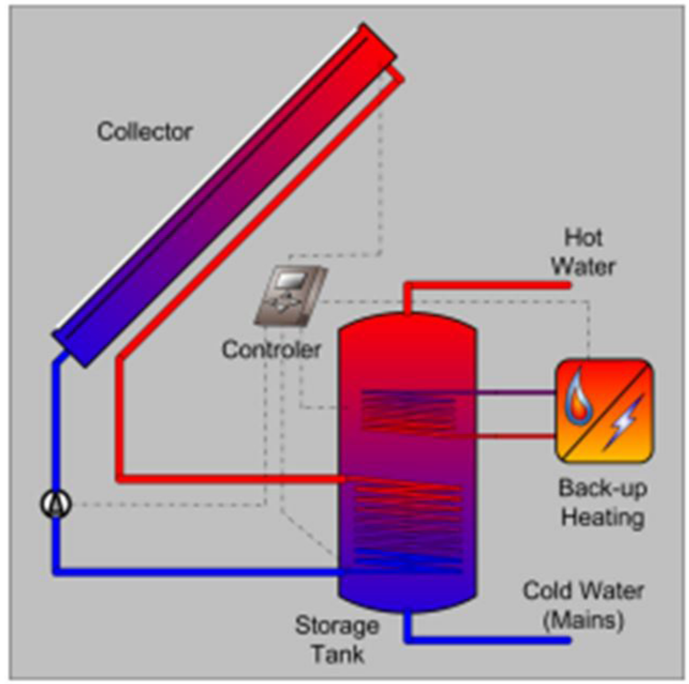


Figure 7: Solar Thermal System

3.3.4 ELECTRICAL SYSTEMS

3.3.4.1 REQUIREMENTS - ENERGY AUTOMATION AND CONTROLS

All new buildings or extensions that will not be operated under GO Transit with a GFA of actively heated and cooled greater than 100m^2 shall:

a) Specify time scheduling for control of electrical and mechanical systems (heating, cooling, lighting, etc.) to automatically control systems to conserve energy. Time scheduling strategies include time-of-day and time-of-year controls;

b) Specify occupancy-based controls for electrical systems such as lighting and specially designated receptacles to conserve energy in unoccupied spaces;

c) Specify occupancy-based controls for ventilation to adjust the amount of fresh air based on the occupancy to conserve energy;

d) Implement electrical and mechanical systems time scheduling functions to allow for automatic switch off at appropriate times to conserve energy; and

e) Specify temperature sensors in all regularly occupied enclosed spaces and connect these sensors to building management systems, where applicable and where heating or cooling is provided.

3.3.4.2 REQUIREMENTS - ENERGY METERING AND MONITORING

The objectives of this section are to allow for accurate energy monitoring and management for new buildings that will not be operated under GO Transit through continuous energy metering and to accurately meter all large energy uses.

All new buildings or extensions that will not be operated under GO Transit with a GFA of actively heated and cooled spaces greater than 100m^2 shall specify:

a) Energy metering for all whole-building energy sources (electricity, natural gas, chilled water, steam, fuel oil, propane, biomass, etc.) used by the asset;

b) Energy metering to independently meter energy loads for individual end uses which are anticipated to exceed 100kW or 10% (per LEED BD+C Advanced Energy Metering Credit.) of total annual consumption of the building;

c) A monitoring system that uses digital metering technology for monitoring of electricity usage. This system shall have the ability to distinguish and monitor electrical information divided into different categories (lighting, mechanical, receptacle loads), different geographic locations (floors, wings, area types), and different times of day;

d) A graphic interface for monitoring electricity usage and for providing an easy-to-understand way of visualizing information. Ability to distinguish and visualize information divided into different categories (lighting, mechanical, receptacle loads), different geographic locations (floors, wings, area types), and different temporal situations (times of day, time periods);

e) A monitoring system interface accessible from Metrolinx office PC workstations;

f) A monitoring system that can monitor building zones independently and be able to distinguish metering data by zone; and

g) Meters that conform either to the Canadian Standards Association (**CSA**) Standard C900 Heat Meter Standard or to the European Committee for Standardization (**CEN**) Standard EN 1434.

3.3.4.3 REQUIREMENTS - LIGHTING

All buildings (new, extensions and reconstructions), sites, and SOGR that will not be operated under GO Transit shall:

a) Use only LED integrated light fixtures and avoid usage of LED retrofit light bulbs, which are generally less energy efficient;

b) Install automatic lighting control systems for exterior spaces;

For interior spaces:

c) Utilize time-of-day and time-of-year lighting controls in non-24 hour occupied locations to reduce energy usage as appropriate for the intended occupancy that are customizable by the facility operator;

d) Utilize vacancy or occupancy sensing solutions in all regularly occupied spaces to reduce unnecessary energy usage;

e) Design lighting zones with high degree of granularity to minimize wasted light; and

f) Utilize natural daylighting as much as possible with consideration of energy consumption requirements and the impact on the natural environment. Minimize use of artificial light when natural daylight is present through the use of photocells and sensors.

3.3.4.4 REQUIREMENTS - GENERAL

Electrical designs for buildings (new, extensions and reconstructions) that will not be operated under GO Transit shall:

a) Avoid oversizing power transformers to control transformers unwanted heat emission; transformers must be sized adequately meeting the asset electrical load requirements plus 50% allowance for potential future growth as required by industry standards;

b) Ensure all dry type power transformers meet the 2019 NRCan Energy Efficiency Regulations levels requirement that energy efficiency percentage which is third party certified is calculated for the 1.2 KV class at 0.35 of the nominal power rating and for the BIL 20-199 kV class at 0.50 of the nominal power. Compliant product models as listed on NRCan's database "https://www.nrcan.gc.ca/energy-efficiency/energy-efficiency-regulations/guide-canadas-energy-efficiency-regulations/dry-type-transformers/6875";

c) Ensure all electric motors meet Canada's Energy Efficiency Regulations published by NRCan, which set a performance standard for their energy consumption; and

d) Utilize variable speed drive (**VSD**) to control motors where required by process.

3.4 SOLAR PV RENEWABLE ENERGY

3.4.1 OBJECTIVES

The objectives of this section are to reduce Criteria Air Contaminants (**CACs**) and GHG emissions associated with energy production and consumption, and provide energy security while also offering the potential to provide an income stream or energy cost off-set during operations.

3.4.2 REQUIREMENTS - GENERAL

a) All new Metrolinx buildings meeting the following parameters, shall design on-site Solar PV renewable energy system to supply, or off-set through net metering, a minimum of 5% of the building's total energy load:

- Where Metrolinx is responsible for utility costs post-construction and commissioning;
- With a clear roof area of at least 100m^2, not designed for overbuild, and where a shadow study indicates sufficient insolation;
- Contains an electrical room, a mechanical room or other space adequate to support metering and electrical panel equipment related to the solar PV system;
- Not otherwise implementing a green roof;
- Not otherwise implementing an alternative on site renewable energy production method; and
- Where solar PV is technically feasible.

All Solar PV installations shall:

b) Where the panels will be placed on the roof, design roofs for solar PV installations, including load checks, roof shape, size and orientation; design drawings shall identify area for solar PV installations.

c) Orient sloped roofs, if applicable, to face south to ensure sunlight will strike the solar collector at an optimal angle;

d) Locate roof accessories and structures to minimize shading on solar PV panels and any areas designated for future solar PV panels. Where shading onto the building is anticipated, hourly analysis software shall be used, such as PV Watts or IESVE. Where shading onto the building is not anticipated, software using average daily statistics is acceptable, such as RETScreen;

e) Allocate space for renewable energy equipment as follows:

1. Space on roofs and electrical rooms including space for conduits and cable trays;

2. Space in electrical rooms for solar PV is in addition to spare wall space requirements per other Metrolinx standards; and

3. Space in the main electrical service for the interconnection of solar AC disconnection box.

f) Avoid running mechanical piping such as plumbing, HVAC and water above the areas preserved for solar PV equipment in electrical rooms to eliminate damage from potential leak or condensation;

g) Provide two spare conduits from the roof to main electrical room, in additional to spare conduit requirements from other Metrolinx Standards, sized based upon potential capacity of future solar PV;

h) Avoid running mechanical services above solar PV equipment in electrical rooms unless these mechanical services are required to support the PV equipment (e.g.: fire protection services, cooling, etc.);

i) Use energy modeling per section 3.1 to estimate the design building electric power demands profile;

j) Solar PV installation shall incorporate an advanced energy metering system with data logging and monitoring capability of string-level data or individual PV module's data in the case of micro-inverters; and

k) Comply with the following requirements. Recognizing that the PV technology is an evolving and rapidly improving industry, the listed must be considered as minimum requirements and all reference must be updated to the latest current at the time of a given project:

1. Lightning Protection: PV installation must be bonded to ground according to manufacturer instructions and CEC;

2. Access, pathways, and smoke ventilation must be as per the Canadian National Building Code (NBC) and the National Fire Code of Canada. Access and spacing requirements must be observed in order to: ensure access to the roof, provide pathways to specific areas of the roof, provide for smoke ventilation opportunities area, and, where applicable, provide emergency access egress from the roof; and

3. The electrical systems analysis and studies must account for and incorporate the solar PV system and components in the various performed analysis. This includes but not limited to short circuit study, power flow study, protection coordination study, arc flash analysis, power quality and harmonics assessment.

3.4.3 REQUIREMENTS - SOLAR PV MODULE

All solar PV modules shall meet the following requirements:

a) PV modules and panels must be of minimum performance in accordance with International Building Code, International Residential Code, CSA C22.1, Safety Standard for Electrical Installations, Canadian Electrical

Code, Part 1, and the National Building Code of Canada, ULC/ORD-C1703 Flat-Plate Photovoltaic Modules And Panels;

b) Be of one of the following panel types:

- Monocrystalline: Listed to ULC/ORD-C1703 Flat-Plate Photovoltaic Modules and Panels; and
- Polycrystalline: Listed to ULC/ORD-C1703 Flat-Plate Photovoltaic Modules and Panels.

c) Bypass diodes shall be built into each PV module either between each cell or each string of cells;

d) Hail Protection: PV modules must be in compliant with testing procedure per ASTM E-1038, Standard Test Method for Determining Resistance of Photovoltaic Modules to Hail by Impact with Propelled Ice Balls;

e) Be coordinated with Utility for local utility-specific requirements; and

f) Be designed to withstand wind gusts of up to 120 km/hr.

3.4.4 REQUIREMENTS - SOLAR PV INVERTER

All solar PV inverts shall:

a) Be designed and installed in compliance with the latest versions of:

- The Canadian Electrical Code;
- CAN/CSA-C22.2 No. 257 Interconnecting Inverter-Based Micro-Distributed Resources to Distribution Systems;
- UL 1741-10 Standard for Inverters, Converters, Controllers and Interconnection System. Equipment for Use with Distributed Energy Resources; and
- IEEE 1547- Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces and its amendments.

b) Solar PV inverters must be installed in accordance to CAN/CSA-C22.2 NO. 62109-2:16 Safety of power converters for use in photovoltaic power systems – Part 2: Requirements for Inverters;

c) Solar PV inverters must be complete with rated integrated AC and DC disconnect as required by the Canadian Electrical Code;

d) Solar PV inverters and modules must be installed in location restricted to public interference;

e) Solar PV design Intent must be to operate the inverters at 0.95 leading, with option to adjust as required by Utility or to optimize Utility demand charges; and

f) Inverters shall be pure sine wave and not simulated sine wave.

3.4.5 REQUIREMENTS - WARRANTIES

The solar PV electrical system shall have warranties meeting the following requirements:

a) Minimum 10-year manufacturer's warranty against deficiencies in materials and workmanship for modules and inverters; and

b) Minimum 25-year manufacturer's warranty on power output as follows:

- Minimum 90% rated power output for the entire first 10 years; and
- Not less than 80% rated power output for the balance of the 25 years.

3.4.6 GUIDANCE

It is recommended that all projects:

a) Assess strategies to meet the requirements of section 3.5.2, including non-roof Solar PV installations Buildings, where the roof areas is less than 100m^2; and

b) Consider building integrated photovoltaics (**BIPV**) system for glazed fenestration or glazed curtain walls. For such buildings the feasibility of integrating BIPV with existing framing must be carried out. The energy production of BIPV is generally small compared to the conventional PV systems, and as such, a business case may be necessary to justify such installation.

3.4.7 OPTIONS

Projects may consider as applicable and feasible:

a) Design on-site Solar PV renewable energy system to supply, or off-set through net metering, a minimum of 10% of the building's total energy load, particularly for projects targeting LEED certification;

a) Installing solar PV panels on green roofs;

b) Installing bi-facial solar panels above high albedo roofs;

c) Installing battery storage where renewable solar system size is larger than the asset power demand at any point of the day to avoid the need for any solar system curtailment. Battery storage design decision should be coordinated with the recommendations of the energy modeling efforts based on specific electrical utility exporting restrictions, electrical power cost benefit analysis, and GHG emission reduction objectives;

d) Feeding excess energy back to the grid to offset a project's energy consumption and to provide an income stream during operations;

e) Providing shading structures such as canopies in parking lots with solar PV;

f) Installing pole mounted solar panels;

g) Supporting future non-roof renewable energy power installations such as platforms, and parking lots such as through additional spare conduit installation and larger spare space allocation in the electrical room:

1. Allocate space for renewable energy equipment in electrical rooms for solar PV is in addition to spare wall space requirements per other Metrolinx standards;
2. Allocate space in the main electrical service for the interconnection of solar AC disconnection box;
3. Avoid running mechanical piping such as plumbing, HVAC and water above the areas preserved for future solar PV equipment in electrical rooms to eliminate damage from potential leak or condensation; and
4. Provide two spare conduits from the renewable energy equipment location to main electrical room.

h) External lighting be solar powered; and

i) Lighting, heating, ventilation and/or other electrical loads at stand-alone shelters, Station Access Modules and other buildings be solar powered, with battery or grid power back-up.

Clarkson GO Station. On top of the 1,500-space, five-storey parking structure, the roof is entirely covered with solar panels.

Erindale GO Station, 250 kW, Installed 2013

3.5 HEAT ISLAND MITIGATION

3.5.1 OBJECTIVES

The objectives of this section are to reduce the contribution to **heat island** effect of Metrolinx buildings and properties through building design and landscaping elements in order to improve human comfort and energy efficiency on site and in surrounding areas.

3.5.2 REQUIREMENTS

All landscape projects with new or reconstructed hardscapes not being delivered through SOGR shall:

a) Provide a plan and calculations showing at least 50% of the site hardscape (excluding roads, bus loops, PUDO, and surface parking lots) uses any combination of the following strategies:

1. Provide shade from the existing tree canopy or within 10 years of landscape installation. Landscaping (trees) must be in place at the time of operations;
2. Provide shade with solar canopies; please refer to examples included in section 3.5.3;
3. Use hardscape materials with an SRI of at least 29; and
4. Permeable paving (see section 5.2.6).

All building projects (new, reconstruction and expansion) shall:

b) Use a combination of green, **cool roof** or solar PV for at least 75% of available new or reconstructed roof space.

3.5.3 OPTIONS

Projects that will not be operated under GO Transit may consider the following strategies for the remaining hard scape to mitigate the **heat island** effect (parking, bus loops, PUDO, and surface road):

a) Permeable paving (see section 5.2.6);

b) Pavement with an SRI of at least 29; and

c) Shade from the existing tree canopy or new canopy within 10 years of landscape installation.

Solar Carport, Oceanfront Park, Boynton Beach, Florida (Source: lumossolar.com)

4 BUILDING WATER MANAGEMENT

4.1 WATER MODELLING, METERING AND MONITORING

4.1.1 OBJECTIVES

The objectives of this section are to develop a comprehensive understanding of the water consumption, applicable to new and renovated buildings, to encourage the integrated design of high-performance buildings, to reduce the environmental impacts of Metrolinx buildings associated with water consumption and to provide comprehensive documentation of anticipated water consumption of Metrolinx buildings.

4.1.2 REQUIREMENTS

All buildings (new, expansion and reconstruction) with indoor water consumption and that will not be operated under GO Transit shall:

a) Conduct a water audit during the commissioning process to correct issues such as: accuracy of the interface between water meters and the BAS or asset management software and conducting leak detection;

b) Specify a monitoring system that uses digital metering technology for monitoring usage of potable water sources and non-potable (grey-water) sources. This system shall have the ability to distinguish and monitor water consumption information divided into different categories, different locations (floors, wings, functional areas), and different times of day. The monitoring system shall have a capability to generate data trends for a minimum one year;

c) Specify a graphic interface for monitoring portable water usage and for providing an intuitive visualization of information. Ability to distinguish and visualize information divided into different categories, different locations (floors, wings, functional areas), and different temporal situations (times of day, time periods);

d) Specify a monitoring system with a remotely accessible interface via web platform or approved equivalent and shall meet Metrolinx data security requirements. The data should be exportable to Microsoft Excel for use, storage and analysis by Metrolinx;

e) Specify permanent water meters that measure the total potable water and non-potable water use for assets and connect the meters to a monitoring system;

f) Specify water meters for cooling tower make-up water connection and blowdown. Connect the meters to the monitoring system;

g) Specify metering and monitoring of facilities that utilize reclaim water system, so that the true reclaimed water component can be determined; and

h) Specify metering and monitoring of alternate water source such as rain water harvesting system and well water system.

4.1.3 OPTIONS

All buildings (new, expansion and reconstruction) that will not be operated under GO Transit with indoor water consumption may consider the provision of additional water meters for domestic hot water heaters, boiler with annual water use of >100,000 gallons (378 500 liters), potable and non-potable water source for irrigation and indoor plumbing, and connect all meters to the monitoring system.

4.2 WATER EFFICIENT DESIGN

4.2.1 OBJECTIVES

The objectives of this section are to develop a comprehensive understanding of indoor water consumption, applicable to new buildings and renovations of Metrolinx buildings, to encourage the integrated design of high-performance buildings, to increase the overall water efficiency of Metrolinx buildings by reducing the water consumption, to efficiently utilizing alternate source of water and to provide comprehensive documentation of anticipated reduction in overall city water consumption of Metrolinx buildings.

4.2.2 REQUIREMENTS - WATER EFFICIENCY

All buildings (new, expansion and reconstruction) with indoor water consumption shall:

a) Select low-flow plumbing fixtures to reduce overall water consumption by minimum 30% for MSF buildings and 35% for station buildings. Baseline calculations on the volumes and flow rates are shown in Table 4;

b) Provide waterless urinals wherever authority having jurisdiction allows their use. Ensure that the waterless urinals shall only be used in applications where special trap fluid will be adequately maintained; and

c) Design drain piping at 2% slope when specifying low-flow plumbing fixtures, to ensure the plumbing drainage system is easy to maintain and kept clear of blockages.

Table 4: Baseline Water Consumption of Fixtures and Fittings

Fixtures or Fittings	Baseline Flush or Flow Rate (imperial)	Baseline Flush or Flow Rate (metric)	Remarks
Toilet	1.6 gpf	6 lpf	The average flush rate for dual-flush toilets must be calculated as the average flush volume of one full flush and two reduced flushes using a 1:2 (high flush : low flush) ratio.
Urinal	1.0 gpf	3.8 lpf	
Public lavatory (Restroom) faucet	0.5 gpm	1.9 lpm	
Kitchen Faucet	2.2 gpm	8.3 lpm	
Showerhead	2.5 gpm	9.5 lpm	

gpf= gallon per flush
gpm= gallons per minute
lpf= liters per flush
lpf= liters per minute

4.2.3 REQUIREMENTS - CALCULATIONS

All buildings (new, expansion and reconstruction) with indoor water consumption shall:

a) Create a table or plumbing fixture schedule that indicates the flush or flow rate information for each fixture;

b) Gather information such as fixture model, flush or flow rates, percentage of occupants with access to the fixture etc.;

c) Determine project occupancy based on the architectural inputs. Clearly distinguish between the full-time employees and visitors. Report visitors as daily average total;

d) Create a separate table for each subset if the project has different sets of fixtures for different parts of the building. If the fixtures are uniform across the project and restroom access is unrestricted multiple calculations are not necessary; one calculation can cover all building fixtures and occupants; and

e) Estimate the number of days of operations per year.

4.2.4 REQUIREMENTS - COOLING TOWER

All buildings (new, expansion and reconstruction) proposing a cooling tower shall:

a) Specify high efficiency cooling towers with minimum drift and evaporative loss;

b) Target maximum number of cycles of concentration to minimize make-up water quantity. Achieving a minimum of 5 cycles of concentration for make-up water having less than or equal to 200 ppm (200 mg/L) total hardness as calcium carbonate or 3.5 cycles for make-up water with more than 200 ppm (200 mg/L) total hardness as calcium carbonate;

c) Have drift losses not exceeding 0.002% of recirculated water volume for counter-flow towers and 0.005% for cross-flow towers; and

d) Provide a water meter in the make-up to cooling tower to verify water efficiency of the cooling tower.

4.2.5 REQUIREMENTS - RECLAIMED WATER

All buildings (new, expansion and reconstruction) and sites proposing alternative, non-potable water sources shall:

a) Design and install the water reclamation system per CSA standard B.128.1-06/B128.2-06. The water reclamation system shall be complete with filtration units to separate both dissolved and undissolved contaminants such as sediment particles, oil, grease, VOC, metals etc from the reclaimed water;

b) Conduct a water quality test after installation of the water reclamation system. Water quality shall meet or exceed Health Canada's "Canadian Guidelines for Domestic Reclaimed water for Use in Toilet and Urinal Flushing;"

c) Calculate the total annual projected water savings using the following calculation; and

$$\text{Total \% Improvement from Baseline} = \left\{ \frac{\text{Annual baseline water consumption} - \left(\text{Annual design case water consumption} - \text{Annual non-potable water supply} \right)}{\text{Annual Baseline water consumption}} \right\} \times 100$$

d) Address any changes to the calculated usage demand of seasonal availability or storage capacity. If the non-potable water is used for multiple applications for example, flush fixtures and landscape irrigation, a sufficient quantity must be available to meet the demands for all uses. The amount of non-potable water meant for indoor and outdoor uses cannot exceed the total annual non-potable water supply.

4.2.6 GUIDANCE

All buildings (new, expansion and reconstruction) and sites should:

a) Use the following equation for basic indoor water use reduction calculations;

$$\text{Daily water use of each fixture unit} = \left(\text{Fixture flush or flow rate} \right) \times \left(\text{Duration of use} \right) \times \left(\text{Number of users} \right) \times \left(\text{Number of uses per person per day} \right)$$

b) The duration of use, number of users, and uses per person per day must be the same in both the baseline and the design case;

c) Dual flush toilet flush rates shall be calculated as the average using a 1:2 (high flush:lowflush) ratio; and

d) Refer to LEED V4 Reference guide for more details; LEED V4 Indoor water calculator: https://www.usgbc.org/resources/indoor-water-use-calculator.

4.2.7 OPTIONS

All buildings (new, expansion and reconstruction) and sites should:

a) Consider alternatives to potable water sources wherever feasible. Alternate water sources include municipally supplied reclaimed water, rainwater, storm water, and foundation dewatering water;

b) Consider reclaimed water as a potential alternate source of water for facilities that have high demand of water for vehicle wash bays (Figure 8). Waste water from the vehicle wash could be reclaimed, filtered and stored to re-use for future vehicle washes. The vehicle wash system shall be designed in a way to utilize reclaimed water. Waste water through trench drain is collected in a sediment settling tank. The sediment settling tank will separate the bigger sediment particles. Submersible sump pumps in the sediment settling tank will pump the water through multiple level filtration units where the remaining smaller particulate will be filtered. The water will be stored in the tank to be reused for next wash.

Below is the sample diagram for reclaimed water. The filtration units for the reclaimed water system should be adequately designed to separate both soluble and insoluble contaminants such as solid particulates, dissolved metals, VOC's etc. to ensure water quality to meet acceptable standards. The vehicle wash detergent should be a biodegradable type detergent and should be suitable for reclaimed water system; and

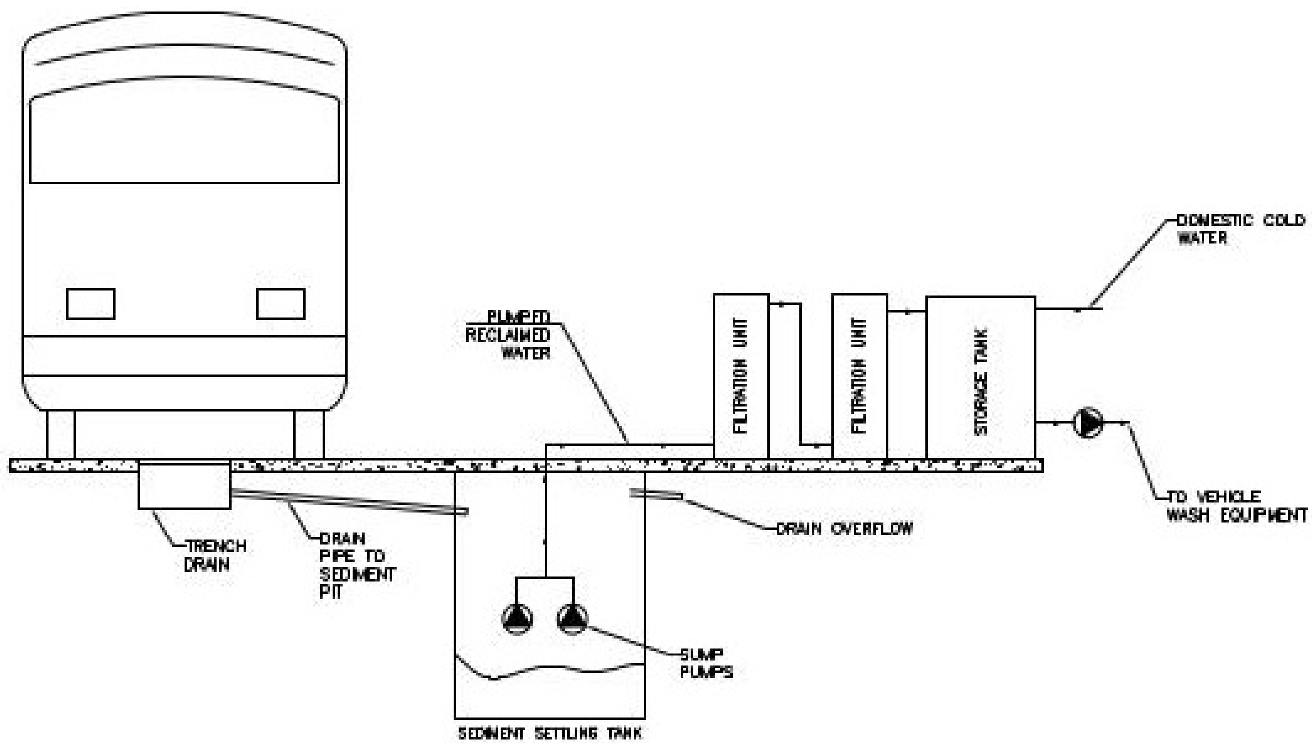


Figure 8: Example vehicle wash reclaimed water system

c) Consider roof rain water harvesting. Rain water collected from a roof could be used for providing an alternate source of water for toilets and irrigation. Rain water collected off a roof to be filtered to an acceptable level before storing it in a collection tank. From the collection tank the water shall be distributed in washrooms for toilet and urinal flushes and/or irrigation. A separate grey water distribution system shall be designed to supply water for toilets and irrigation. Based on the type of facility, roof catchment area and grey water demand for the facility, designer to perform a **life-cycle cost analysis** and feasibility study to assess the cost effectiveness of rain water harvesting system over 20 years of time frame.

Rainwater that will be used as grey water for toilets shall be collected only from impervious roofing surfaces constructed from approved materials. Rain water harvesting off the green roof is only permitted if the grey water is used only for irrigation.

The flush valves for the water closets and urinals should be a geared type of a diaphragm type to ensure better screening of solid particles.

The overflow drain from the sediment settling tank should be passed through an oil separator before connecting to building sanitary drain.

5 STORM WATER MANAGEMENT

5.1 STORM WATER PERFORMANCE CRITERIA

The climate is changing. The intensity and frequency of weather-related natural disasters has led to concerns about how prepared the public and private sectors are for an event. High-intensity storm events, floods, and droughts are subjecting population centers to more risk. Climate change is already having an impact throughout the GTA and Southern Ontario and is expected to continue into the foreseeable future. Changes in temperature, precipitation and lake levels, however, are not uniform – there is great variability in what climate change will mean depending on location. Systems being impacted will also differ in their sensitivity to climate stresses, and these may vary by location. Determining the regional and local effects of global climate change is critical to assessing **vulnerability** and risk, which is necessary information in order to create implementable strategies.

Confidence levels in projections of future climate conditions vary considerably, with higher confidence in temperatures, followed by precipitation and then lower confidence for other extreme weather events such as snow- and ice-storms. The notion that weather will become "warmer", "wetter", and "wilder" is widely accepted, but the details of how precipitation will change, and the associated flood events, are less certain. Annual precipitation will increase, storm events will become more frequent and intense, and yet droughts could occur more often. There is growing acceptance of applying projections in Intensity-Duration-Frequency (**IDF**) statistics to inform storm water system design, and to consider a broad range of measures to address increased flood risk and exposure.

5.1.1 OBJECTIVES

The overall objective is to enhance hydrological and hydraulic analyses to incorporate unbiased assessments of future climate change and account for uncertainties in the projections; the enhanced storm water criteria may be stricter than those from Authorities Having Jurisdiction.

5.1.2 REQUIREMENTS - GENERAL

All projects otherwise preparing a storm water management report, shall:

a) Review current climate change projections before incorporating climate change into any design, as the science behind projections of future extreme precipitation are rapidly evolving, and better estimates for a specific location may be available;

b) Incorporate science-based, documented, repeatable processes to climate change considerations into storm water management planning;

c) Develop all hydrological and hydraulic modelling in collaboration with the local regulatory agencies to ensure proper development of the updated computer models;

d) Design storm water management controls to safely convey storm water discharge, while minimizing flooding and erosion impacts on adjacent properties; and

e) Develop an O & M manual for each site for storm water infrastructure. O & M manual shall contain an O & M schedule, and shall provide direction on the regular maintenance of all installed SWM infrastructure as per manufacturer's requirements, if necessary, to maximize its effectiveness. Training shall be provided to staff prior to operation.

5.1.3 REQUIREMENTS - WATER QUANTITY

All projects otherwise preparing a storm water management report, shall:

a) For **minor storm** conveyance, apply one of the following approaches to the **IDF** curves for the 2, 5, 10, 25, 50, and 100-year return period storm events for water quantity conveyance to account for the range of possible climate change outcomes:

   1. Apply additional 25% to the peak flow for the **minor design storm**, determined using existing IDF information from Environment Canada, Ministry of Transportation IDF web application (http://www.eng.uwaterloo.ca/~dprincz/mto_site/terms.shtml); or

   2. Apply IDF curve modifications as per CSA Plus 4013:19 (Technical Guide: Development, Interpretation and Use of Rainfall Intensity-Duration-Frequency (**IDF**) Information).

b) For storage and controlled discharge of all storm events, apply one of the following approaches:

   1. Include an additional 20% to the rainfall amount for the 100-year, 24-hour storm event (equally distributed over the 24-hour period) to account for the range of possible climate change outcomes; or

   2. Utilize rainfall amounts for Representative Concentration Pathway (**RCP**) 8.5 future climate scenarios from the University of Western Ontario and the Canadian Water Institute IDF CC Tool for deriving rainfall Intensity-Duration-Frequency Curves (http://www.idf-cc-uwo.ca/default.aspx).

5.1.4 GUIDANCE - WATER QUANTITY

Examine the merits of relocating project elements throughout the design process to address varying soil conditions and other constraints across the site and maximize achievable volume control.

5.1.5 REQUIREMENTS - WATER BALANCE

All projects otherwise preparing a storm water management report, shall:

a) Mimic pre-development infiltrative capabilities by incorporating a **treatment train** approach, which utilizes a combination of lot-level, conveyance, and end-of-pipe storm water management measures to achieve the water quality and water balance target for Site development;

b) For developments without restrictions, control, capture and retain on-site storm water runoff volumes for a 25 mm, 24-hour rainfall event from the post-development total on-Site impervious area; and

c) For developments with restrictions, control, capture and retain storm water runoff volumes for a 10 mm, 24-hour event from the post-development total on-Site impervious area. Proper documentation, such as geotechnical reports and hydrogeological reports, should be provided for technical review to illustrate on-Site restrictions. Acceptable restrictions include:

1. High groundwater (less than 1.0 m between the obvert of the infiltratative measure to the seasonally high groundwater table);
2. Shallow Bedrock or Karst geology;
3. Poor soils with infiltration rates <15 mm/hr or >150 mm/hr;
4. Zoning, property and infrastructure restrictions; and
5. Source Protected Areas designated by the local conservation authorities, such as Wellhead Protection Areas (**WHPA**), Highly Vulnerable Aquafor (**HVA**), and Significant Groundwater Recharge Area (**SGRA**).

5.1.6 GUIDANCE - WATER BALANCE

All projects otherwise preparing a storm water management report, should:

a) Maximize on-site infiltrative capabilities. To the greatest extent possible, the pre-development water balance should be maintained, returning annual precipitation volumes of runoff, evapotranspiration and infiltration in proportions, keeping with site conditions prior to development; and

b) Utilize long-term climate data in modelling LIDs to meet water balance requirements. Modelling tools available include LID TTT Tool (http://www.sustainabletechnologies.ca/wp/low-impact-development-treatment-train-tool/) and Environment Canada (EC) climate data and methodology developed by Thornthwaite and Mather (1955).

5.1.7 REQUIREMENTS - WATER QUALITY

All projects otherwise preparing a storm water management report, shall:

a) Incorporate a treatment train approach to addressing addressing project water quality requirements total suspended solids (**TSS**) discharging off-Site;

b) Implement pre-treatment infrastructure upstream of all Low Impact Development (**LID**) controls and SWM facilities (see section 5.2). Catch basin filters, oil grit separator (**OGS**) units, sediment forebay, and 'isolator rows' within underground SWM facility units are suitable pre-treatment controls. If phosphorus filtration system units are required, position phosphorus filtration system units downstream of all SWM controls, prior to discharging off-Site. LID controls receiving concentrated underground flow shall install an OGS unit(s) as pre-treatment; and

c) Minimize thermal impacts and limit discharge temperatures, with respect to the type of stream and aquatic habitat noted in the stream. Consult with the Ministry of Natural Resources and Forestry and the local conservation authority for stream information and permitting requirements, if not already done through a TPAP.

5.1.8 REQUIREMENTS - FLOOD MITIGATION

All projects that must determine a floodplain, shall:

a) apply the greater of the following storm events to account for the range of possible climate change outcomes to the high-water riverine flood elevation:

- Regional storm (designated by the local conservation authority); or
- 25% increase in the peak flow indicated within the approved hydraulic model for the 100-year storm event.

b) For slope and channel bank protection along sites and downstream of the outlet structure, utilize the shear stress and velocities calculated for the flood mitigation event indicated above to properly select appropriate slope protection material.

5.2 LOW IMPACT DEVELOPMENT PRACTICES

5.2.1 OBJECTIVES

The objectives of this section are to support sites in meeting the storm water performance criteria in section 5.1 and broadly support climate change adaptation and mitigation. The LID practices manage storm water run-off from new or reinstated ground surfaces and roof areas, provide quality treatment of storm water run-off, and support infiltration, re-use and evapotranspiration of storm water. LID strategies shall prioritize minimizing their life-cycle costs while enhancing their many co-benefits. The Green Roof LID design direction focusses on reduction of building energy consumption, heat island effect mitigation, enhancing storm water storage and treatment, and provision of habitat.

This section provides a list of potential LID practices on Metrolinx sites, but is not an exhaustive list.

5.2.2 REQUIREMENTS - GENERAL

All projects proposing LIDs shall:

a) Provide at project handover a maintenance and inspection manual for each LID practice covering the asset life-cycle;

Plant selection criteria in LID practices shall:

b) Be drought tolerant plants;

c) Be salt tolerant at locations likely to receive higher salt loads, including spray and direct run-off;

d) Be native species. Up to 50% introduced (non-native) species may be proposed in LID practices with restricted or harsh planting conditions and that do not have a direct connection to a natural heritage system;

e) Contain no invasive species;

f) Be appropriate to local climate conditions;

g) Be resilient and low maintenance; and

h) Avoid monocultures.

5.2.3 GUIDANCE - GENERAL

All projects proposing LID practices should:

a) Incorporate vegetation;

b) Incorporate storm water infiltration where supported by the soil characteristics and groundwater; and

c) Design per recommendations in the *Low Impact Development Stormwater Management Wiki* co-developed by the Credit Valley Conservation authority, the Toronto and Region Conservation Authority, and the Lake Simcoe Region Conservation Authority (wiki.sustainabletechnologies.ca).

5.2.4 OPTIONS - GENERAL

Compare the life-cycle cost of low impact development practices against traditional, end-of-pipe storm water management practices (see also section 2.1).

5.2.5 GREEN ROOF

5.2.5.1 REQUIREMENTS

All buildings (new, expansions and reconstructions) proposing a green roof shall:

a) Green roofs proposed on buildings and facilities that will be operated under GO Transit, shall be designed to reduce operational energy costs;

b) Provide a green roof implementation feasibility study;

c) Adhere to the following plant selection criteria:

   1. Meet the requirements of section 5.2.2;
   2. Consider building exposure;
   3. Exclude species that present potential fire risk;
   4. Use a minimum of five plant species; and
   5. Select native species that provide pollinator habitat to the extent feasible while prioritizing plants that are adaptable, drought tolerant and low maintenance.

d) Utilise pre-vegetated modules or plugs; seeding applications shall not be accepted;

e) Design an extensive green roof, tolerant for extreme climate conditions such as heat, drought, cold stress, freeze and wind;

f) Utilize a modular system. Implementation of a non-modular system is more suitable for the project is subject to Metrolinx approval based on the alternative being more suitable for the site;

g) Use pre-vegetated modules or plugs for immediate planting cover. Higher planting density deters the establishment of weeds;

h) Provide fire resistance and wind uplift study reports for the selected green roof system;

i) Design the green roof to not be accessible to the public;

j) Use growing media depth that ranges from minimum 60mm (2-1/2”) to maximum 150mm (6”). Note that generally a depth up to 108mm (4-1/4”) will be sufficient and appropriate;

k) Undertake the design in consultation with a professional horticulturist or green roof consultant and other professionals (architects, structural, civil, mechanical and other engineers); and

l) If Metrolinx is to perform ongoing maintenance of the green roof after the warranty period, an Operation and Maintenance Manual specific for the project green roof system shall be provided. It shall address the following operations:

1. Irrigation – amount, time and control;
2. Weeding – frequency and type of weeds to be removed;
3. Plant replacement (if required);
4. Fertilization (where required) – amount, frequency and type;
5. Herbicides, insecticides, fungicides should be avoided or used sparingly;
6. Inspection of drains, edging, roof penetrations, flashing and non-planted areas; and
7. Assignment of responsibility for removal of, care for, and re-installation of growing medium and vegetation in the event of a leak.

5.2.5.2 GUIDANCE

All buildings (new, expansions and reconstructions) implementing a green roof should:

a) Design the green roof to cover a minimum 50% of available roof space; and

b) Design a **cool roof** on areas of available roof space not covered by the Green Roof (see section 3.5).

5.2.5.3 OPTIONS

a) All buildings (new, expansions and reconstructions) implementing a green roof may co-locate the green roof with a Solar PV system or a water retention system. Co-located systems can maximize benefits, particularly on space constrained sites. In addition the moderated temperature on a Green Roof supports a higher operating efficiency for the Solar PV panels;

b) Where a Green Roof co-located with solar panels is under consideration, projects may consider performing a study of feasibility and of the relative benefits of combining solar panels and a green roof on top of the building compared to using just one of the options alone; and

c) Undertake a life-cycle analysis comparing the life-cycle cost and energy performance against non-green roof installations.

5.2.5.4 DESIGN DIRECTION

a) Green Roof Assembly shall, as a minimum, consist of a root repellent system, a drainage system, a filtering layer, a growing medium and plants. It shall be installed on waterproof membrane of an applicable roof (Figures 9 and 10).

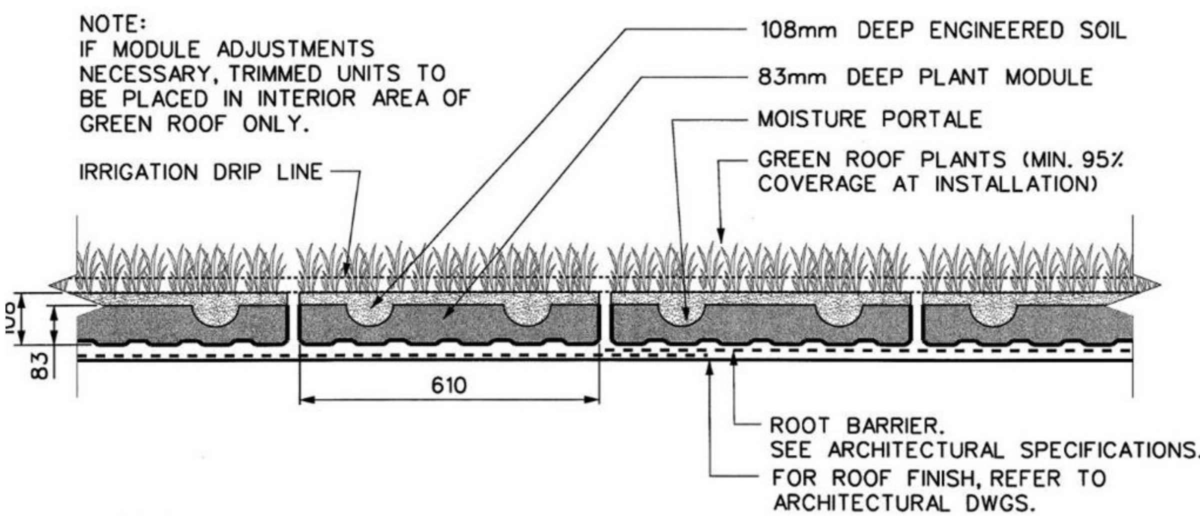


Figure 9: Typical Pre-vegetated Green Roof Module (Source: AECOM)

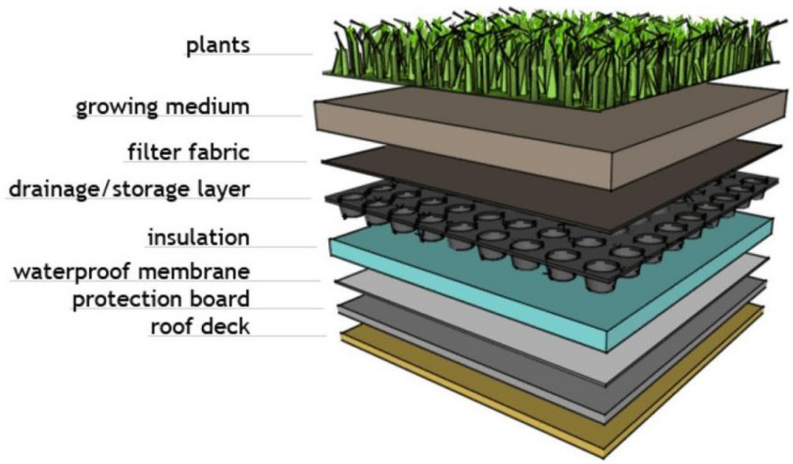


Figure 10: Basic Green Roof Assembly (Source: Roofgenious)

Extensive Green Roof Planting

b) Green Roof shall accommodate:

   1. Perimeter safety gap for the operations and maintenance;

   2. Minimum 600mm wide vegetation free zone shall be installed at the perimeter of the roof; and

   3. Minimum 300mm wide vegetation free zone shall be installed around all roof penetrations to act as a fire break and prevent roots intrusion.

c) Roof drains shall:

   1. Be protected from vegetation coverage or loose soil or gravel which can obstruct the drain; and

   2. Be designed to allow regular inspection and maintenance.

d) Irrigation shall:

   1. Be customized for the project green roof system based on the intended use of the roof, choice of plant material, media depth, environmental conditions and budget; and

   2. Be water efficient.

e) Green Roofs with Solar Panels shall:

   1. Be restricted to low-profile vegetation on a flat roof with solar PV panels. The solar panels should be installed above the vegetation level so that the panels are not shaded; and

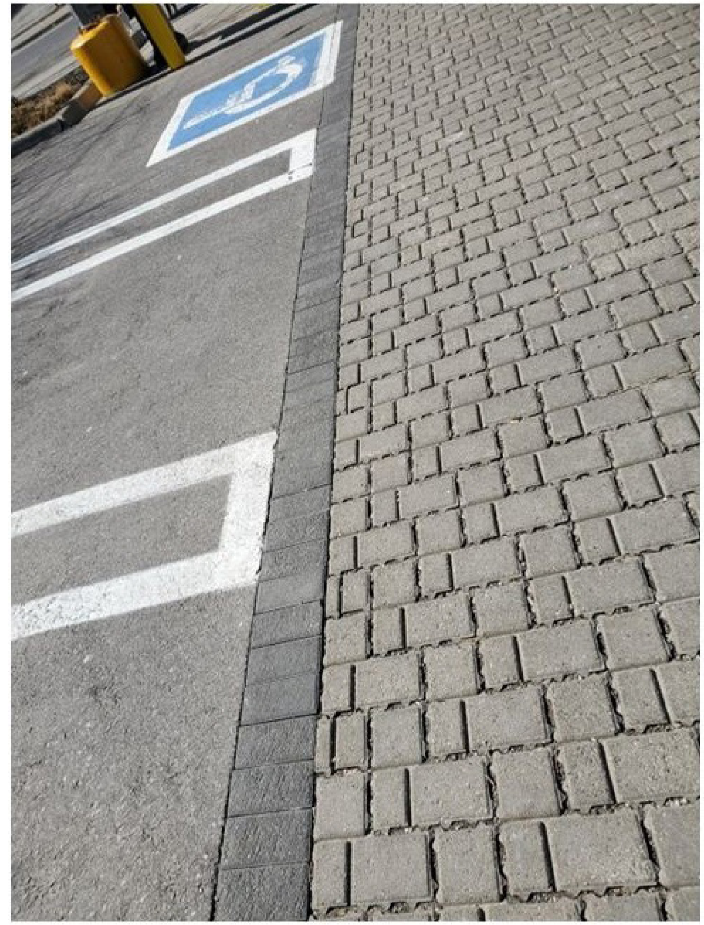
   2. Have shade-tolerant vegetation under the solar panels if the frames are used to raise and tilt panels towards the predominant direction of the sun. Passive or active irrigation of the vegetation shall be provided.

Solar Panels on Green Roof (Image Source: Greenwood at medium.com)

5.2.6 PERMEABLE PAVING

Permeable paving is a permeable hardscape that allows storm water infiltration through the surface into a stone reservoir. Permeable paving includes:

- permeable interlocking concrete pavers (**PICP**) - impermeable concrete units with inter-block voids filled with open-graded aggregate;
- plastic or concrete grid systems – a grid system with large pore spaces that can be planted or filled with aggregate;
- pervious concrete – concrete with a high porosity; and
- pervious asphalt – asphalt with a high porosity.



PICP at Green P lot, North of Dundas Street West at Manning Avenue

Concrete Open Grid (source: alamy.com)

Permeable Concrete Paving at Lakeside Park, Mississauga (Source: wiki.sustainabletechnologies.ca)

5.2.6.1 REQUIREMENTS - GENERAL

a) Pervious asphalt, pervious concrete and pervious pavers shall be restricted to areas of low vehicular and pedestrian traffic volumes with lower frequency of winter maintenance, such as a maintenance access road/path;

b) Grassed open-grid pavers shall be restricted to areas of very infrequent vehicular or pedestrian traffic with no winter maintenance, such as emergency access roads or maintenance/access roads around storm water ponds;

c) Except as noted above, all **permeable paving** shall be permeable interlocking concrete pavers (**PICP**). PICP are generally appropriate in areas of higher traffic volume and foot traffic, and higher winter maintenance requirements. PICP shall be concrete units with inter-block voids filled with open-graded aggregate;

d) For locations to be operated under GO Transit, permeable paving shall not be permitted in areas of public vehicular parking and movement;

e) Pavers shall be locally available to facilitate for maintenance;

All permeable paving designs shall:

f) Not be in areas that are subject to contamination, or downstream of potential contamination , including areas for fuel storage and refueling;

g) Be designed in accordance with applicable Source Water Protection requirements;

h) Not receive runoff from landscape areas. Adjacent landscape areas shall be graded to drain away from the **permeable paving** to prevent sediments from running into the permeable surface and clogging the pore spaces;

i) Be designed such that the impervious area draining to the pervious area does not exceed 1.2 times the receiving area;

j) Be located downslope of building foundations;

k) Be located at least 4m away from building foundations if they receive runoff from other surfaces;

l) Be designed to accommodate underground utilities where applicable;

m) Meet the run-off storage, infiltration and structural design criteria for the application;

n) Allow for overflow or storm water conveyance when the surface is overloaded or clogged;

o) Be designed to allow for annual inspections and maintenance with monitoring wells, and inspection and cleanout ports connected to the sub-drain system at recommended intervals;

p) Be designed and installed to minimize uneven settlement and trip hazards;

q) Be designed and installed with the sub-base recommended by the manufacturer for the proposed use to eliminate any differential settlement or unevenness in surface;

r) Underlay PICP and open-grid pavers in areas of vehicular traffic with a geogrid;

s) Adjacent surfaces and materials to be flush and level with pavers, unless otherwise indicated in the design. Adequate edging shall be used to ensure no lateral or vertical movement of pavers;

t) Meet AODA requirements by providing a firm, stable, slip resistant surface that canes, crutches, or the wheels of mobility devices will not sink into;

u) Be heel proof with openings less than 13mm wide;

v) Have a surface slope of between 1% and 5%;

w) Be accompanied by a construction plan to provide requirements for protection during construction;

x) Be accompanied upon hand-over to Metrolinx by a maintenance schedule for the permeable paving;

y) Be designed to minimize life-cycle operations and maintenance costs; and

z) Be designed to withstand vehicle loads, including maintenance vehicles, where vehicular use is anticipated.

5.2.6.2 REQUIREMENTS - PERMEABLE INTERLOCKING CONCRETE PAVERS

The design of PICP shall tightly abut the edge restraints to prevent spreading of joints. Concrete edge restraints shall be used over plastic or metal.

5.2.6.3 REQUIREMENTS - STONE RESERVOIR

The design of the stone reservoir shall:

a) Be such that the base of the stone reservoir is at least one meter above the seasonally high-water table;

b) Incorporate a non-woven needle punched or woven monofilament geotextile fabric to separate the stone reservoir and native soils;

c) Consist of clean washed stone. The cross-section shall be as per recommendations of the geotechnical and storm water management report; and

d) Be a flat bottom when designed for full infiltration, and may be sloped at 1% to 5% when designed for partial infiltration.

5.2.6.4 OPTIONS

Projects may provide passive irrigation for new plant material on site through designing adjacent soil cells for tree pits to receive a portion of the storm water infiltrated through the **permeable paving**.

5.2.6.5 DESIGN DIRECTION

Figure 11 illustrates required components of PICP in cross section. The cross section of open-grid, and pervious asphalt or concrete will vary in the upper layers from this cross section.

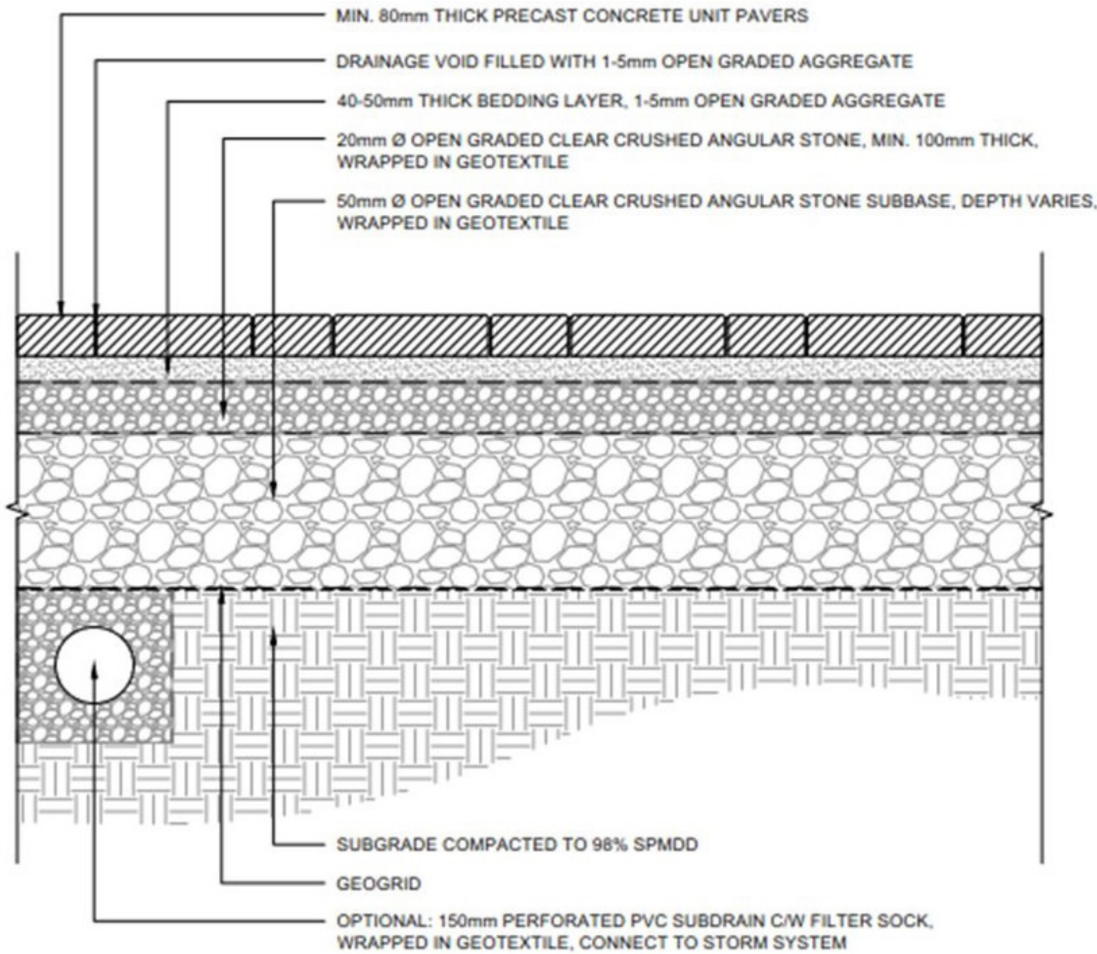


Figure 11: Permeable paving cross-section

5.2.7 BIORETENTION CELLS

Bioretention cells are also known as Rain Gardens and are non-linear systems without underdrains. Bioretention cells are ideal to receive roof run-off and as source control in smaller drainage areas between 100m^2 to 0.5 hectares.

5.2.7.1 REQUIREMENTS

All Bioretention cells shall:

a) Meet the requirements of section 5.2.2;

b) Include an overflow capture device to handle flows from larger storm events; the overflow inlet shall be at a minimum 150 mm above the filter bed;

c) Not be used as an end-of-pipe control;

d) Have a ratio of impervious drainage to bioretention cell area from 5:1 to 15:1;

e) Have side slopes of no steeper than 2:1;

f) Provide access, visibility and maintenance laydown areas for any manholes, handwells, maniford chambers, and catch basins located within the Bioretention cell; and

g) Where the bioretention is not receiving clean storm water, install OGS unit(s) as pre-treatment devices to prevent sediment and debris from entering infiltration facilities to avoid clogging and system failure. Where there are site constraints preventing the use of OGS units as pre-treatment, acceptable alternative pre-treatment devices may include Leaf Screens, in-ground filters, or vegetated filter strips or grass swales.

Bioretention Cell capturing and treating runoff from adjacent parking lot (Source: Sustainable Technologies)

5.2.8 INFILTRATION TRENCH – REQUIREMENTS

An infiltration trench is a level, linear trench system which distributes concentrated storm water runoff flow and promotes infiltration to native soils. It is often a channel of decorative stone with a geotextile separating the stone from the native soils. Infiltration trenches are ideal for receiving storm water runoff sheet flow from parking lots and pathways.

5.2.8.1 REQUIREMENTS

All infiltration trenches shall:

a) Install a perforated pipe, unless otherwise recommended by studies of the soil characteristics. The perforated pipe shall have a minimum diameter of 150mm, but recommended diameter of 200mm. Where soil infiltration is not recommended (such as high groundwater), the perforated pipe shall be placed at the base of the reservoir aggregate; otherwise the perforate pipe shall be placed at an appropriate depth above the base of the reservoir aggregate to support infiltration;

b) Protect adjacent subsurface infrastructure by maintaining an appropriate minimum clearance or by constructing a deep curb to separate the roadbed subgrade or parallel utility line from the facility;

c) Be filled with 50mm crushed angular clear stone with a 40% void ratio; and

d) Provide access, visibility and maintenance laydown areas for any manholes, handwells, maniford chambers, and catch basins located within the infiltration trench.

5.2.9 BIOSWALE

Bioswales (vegetated swales) are linear bioretention systems conveying storm water flows. Bioswales filter are effective at filtering pollutants from storm water runoff to improve water quality prior to discharge to receiving natural systems, and can be designed to control velocities.

5.2.9.1 REQUIREMENTS

All bioswales shall:

a) Meet the requirements of section 5.2.2;

b) Contain engineered soil mixture with a maximum clay content of 5%;

c) Have a bottom (base) width of 0.75m to 3m;

d) Have a side (longitudinal) slope a minimum of 3:1 to allows sediments and pollutants to settle; a side (longitudinal) slope of 4:1 is recommended;

e) Provide an overflow capture device to handle flows from larger storm events; the overflow inlet shall be a minimum 150 mm above filter bed;

f) Install OGS unit(s) as pre-treatment devices to prevent sediment and debris from entering infiltration facilities to avoid clogging and system failure. Where there are site constraints preventing the use of OGS units as pre-treatment, acceptable alternative pre-treatment devices may include Leaf Screens, in-ground filters, or vegetated filter strips or grass swales;

g) Install a perforated pipe, unless otherwise recommended by studies of the soil characteristics. The perforated pipe shall have a minimum diameter of 150mm, but recommended diameter of 200mm. Where soil infiltration is not recommended (such as high groundwater), the perforated pipe shall be placed at the base of the reservoir aggregate; otherwise the perforate pipe shall be placed at an appropriate depth above the base of the reservoir aggregate to support infiltration;

h) Be designed to enhance evapotranspiration, such as with smaller cells to slow down water, where infiltration is not feasible;

i) Incorporate vegetation to enhance water quality reatment; and

j) Provide access, visibility and maintenance laydown areas for any manholes, handwells, maniford chambers, and catch basins located within the bioswale.

5.2.9.2 OPTIONS

All bioswales may:

a) Implement a cascade-pool design to allow for water detention/variance/dissipation of energy during high-flow events; and

b) Incorporation of compost filter socks to enhance pollutant removal and vegetative growth.

Bioswale along County Court Boulevard in Brampton (source: wiki.sustainabletechnologies.ca)

5.2.10 STORM WATER DETENTION ROOFS

Storm water detention roofs are also known as blue roofs and are designed to retain storm water. They can be co-located with green roof installations. Storm water detention roofs should be considered where sufficient storm water retention cannot be provided off the building.

5.2.10.1 REQUIREMENTS

All storm water detention roofs shall:

a) Provide maintenance walkways to enable access while roof is holding water as required

b) Provide waterproofing 150 mm above the peak ponding elevation;

c) Be a maximum 2% slope;

d) Achieved water retention using flow control devices such as drain covers, small check dams, weirs, and modular tray systems; and

e) Have a fully separated controlled layout from any solar PV or solar thermal systems.

5.2.10.2 DESIGN DIRECTION

Figures 12 and 13 demonstrate potential roof structure for blue roof design.

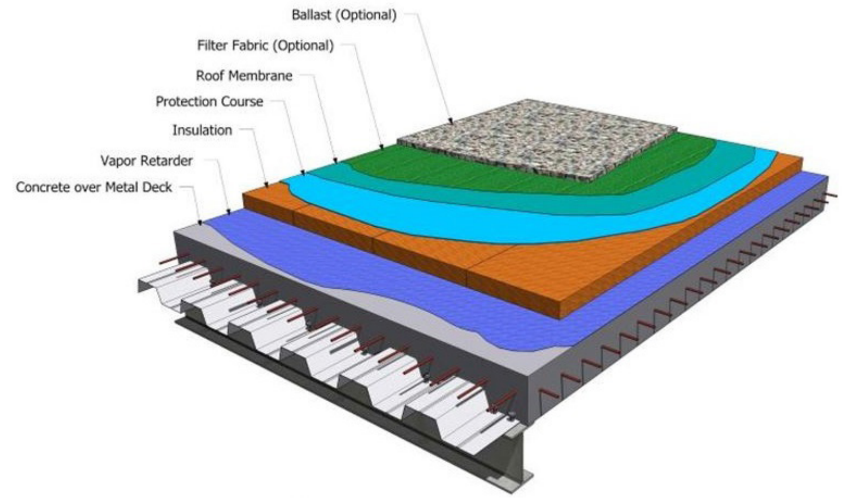


Figure 12: Conventional Blue Roof Assembly for illustration purposes only

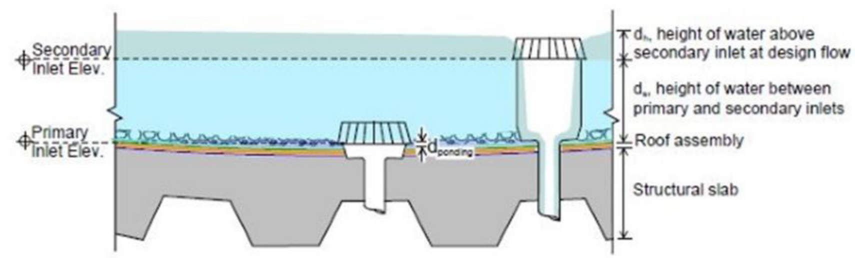


Figure 13: Detained water levels on a Blue Roof for illustration purposes only

5.2.11 CISTERNS AND RAIN BARRELS - REQUIREMENTS

Cisterns shall be sized based on supplying a minimum percentage of demand (i.e. **greywater** system shall provide 100% of irrigation demand).

5.2.12 MANUFACTURED, STRUCTURAL LIDS - REQUIREMENTS

Manufactured, structural LID practices include soakaway pits, infiltration chambers and perforated storm water pipes.

a) Soakaway pits and infiltration champers shall have level bed bottoms; and

b) Infiltration chambers shall have manholes and inspection ports to provide access for monitoring and maintenance activities.

All manufactured, structured LID practices shall:

c) Install OGS unit(s) as pre-treatment devices to prevent sediment and debris from entering infiltration facilities to avoid clogging and system failure. Where there are site constraints preventing the use of OGS units as pre-treatment, acceptable alternative pre-treatment devices may include Leaf Screens, in-ground filters, or vegetated filter strips or grass swales;

d) Install inlet and overflow outlets to facilities below the maximum frost penetration depth to prevent freezing; and

e) Design outlet pipes with a capacity equal to or greater than the inlet pipes.

6 ECOLOGY

6.1 SOIL MANAGEMENT

6.1.1 OBJECTIVES

The objectives of this section are to protect and restore soil health during construction, operation and maintenance to support healthy vegetation and storm water infiltration. Soil health is a function of the composition, function and structure of soils, including a healthy soil microbial ecosystem. For the purposes of this section, soils support vegetation growth and storm water infiltration.

6.1.2 REQUIREMENTS

a) All designs and specifications for tree planting shall provide a minimum volume of $30m^3$ of high quality soil per tree, with a minimum soil depth of 0.8 m and a maximum of 1.2 m of high quality soil above a well-drained sub-soil or drainage layer. The minimum soil volume can be 20 m^3 where the soil volume is shared; and

All projects proposing **LID** practices for storm water infiltration into native soils or that are disturbing a minimum $100m^3$ of native soil to receive seeding and/or planting, shall:

b) Prepare and submit at no later than 90% design a soil management plan. The plan shall:

   1. Minimize impacts to soil health during construction, including soil compaction;
   2. Provide requirements for soil stockpile management to preserve the integrity of excavated soils;
   3. Restores the health of soils degraded during construction or previously degraded;
   4. Be developed in conjunction with landscaping construction plans to ensure the project life-cycle of soil management is achieved through construction, post-construction restoration and future management and maintenance;
   5. Ensure that soils are fit for purpose (including the needs of the vegetation it is supporting, the activity of people using the site, and the current and future climate conditions);
   6. Ensure soil infiltration rates and pollution adsorption capacity of soils are protect and restored;
   7. Incorporate recommendations from testing of the existing soil to determine the agricultural properties; all areas to receive seeding or planting shall complete soil sampling and agricultural testing of existing on-site soils (or clean fill materials) for to provide specific pH and nutrient control recommendations necessary to amend site soils prior to seeding or planting operations; and
   8. Immediately upon completion of LID construction, stabilize with native terraseed.

6.1.3 GUIDANCE

All designs and specifications for tree planting should:

a) Avoid impermeable surface treatments within 1.8m of tree trunks; and

b) Propose that surface treatments within 1.8m of tree trunks be installed once the surrounding area has had the opportunity to establish itself to allow for subsidence effects and to provide direct access for irrigation during establishment. Installation of the final surface two years post-planting is recommended.

Soil management plans should:

c) Increase the organic matter content of the soil through the addition of compost or other organic soil amendments to improve the water-retention capacity of soils supporting vegetation;

d) Protect soil along the edge of the site not essential to construction from compaction and relocation through construction and post-construction; and

e) Support root growth for areas under footpaths, verges and garden beds via quality fit-for-purpose soil preparation including structural soils;

6.2 BIRD FRIENDLY DESIGN

6.2.1 OBJECTIVES

The objective of this section is to reduce anthropogenic bird injury and mortality due to bird strikes and other interactions with Metrolinx structures, and in particular exterior glass surfaces, by introducing bird friendly strategies applicable to new structures and renovations to existing structures.

This section also aims to support improving customer experience and decreasing reputational risk from public sightings of injured or dead birds on Metrolinx property and to reduce Operations and Maintenance costs associated with removal of injured or dead birds.

6.2.2 REQUIREMENTS

All projects proposing new glazing shall:

a) Treat at least 95% of exterior glazing within the first 16m of the building above ground level; exterior glazing treatment includes at least one of the following:

   1. Low reflectance, opaque materials including solid back-painted frit or silicone backing opaque coatings and should have an outside reflectance of 15% or less;
   2. Visual markers applied to the glass with a maximum spacing of 50mm x 50mm, and markers must be at least 5mm in size;
   3. Ceramic frit patterns shall have a high contrast; and
   4. Install building-integrated structures, such as exterior screens, grilles, shutters and sunshades, to mute reflections on glass surfaces.

b) Secure enclosed spaces such as ground level ventilation, with grates/screens with a porosity of less than 20mm x 20mm (or 40mm x 10mm);

c) Avoid interior vegetation in buildings near windows that are visible from outside; and

d) Minimize the use of clear and fritted glazing while meeting other Metrolinx standards and requirements, including for daylighting, CPTED, and architectural expression.

6.2.3 GUIDANCE

To reduce the risk of nighttime collisions, all buildings should minimize unnecessary lighting visible from exterior windows at night time using the following techniques:

a) Avoid placing emergency lighting/night lighting near windows of buildings taller than 3 stories;

b) Utilize occupancy and time-based lighting controls techniques to ensure that any unnecessary lights are turned off; and

c) Increase granularity of dimming zones to allow only necessary lights to remain on in areas that are occupied, without affecting nearby areas that are unoccupied.

6.3 LIGHT POLLUTION REDUCTION

6.3.1 OBJECTIVES

The objective of this section is to minimize the ecological impacts of light pollution. This section is applicable to buildings that will not be operated under GO Transit only.

6.3.2 REQUIREMENTS

All projects for buildings and sites that will not be operated under GO Transit proposing exterior lighting shall:

a) Implement a cohesive and adaptable hierarchy of lighting that achieves other lighting objectives with the minimum light necessary;

b) Restrict light spillage to sensitive areas (i.e. residential or natural habitats) such as through directional lighting or light shields;

c) Meet the IES TM-15-11 BUG (Backlight, Uplight and Glare) classification of outdoor fixtures, and have no glare;

d) Provide a map and worksheet demonstrating BUG ratings meeting lighting zone requirements; and

e) Use exterior light fixtures that meet the IESNA Full Cut-off Classification or an Uplight rating (as a part of the BUG rating system) of zero.

6.3.3 OPTIONS

All projects for buildings and sites that will not be operated under GO Transit proposing exterior lighting AY:

a) Use an appropriate colour temperature to the context of its application (i.e. maximum 3000K in residential areas including mixed-use areas with residences, maximum 4000K along high traffic arterial roads); and

b) Use fixtures with a Dark Sky Fixture Seal of Approval where a maximum CCT of 3000K is appropriate.

All projects for buildings (new, expansion and reconstruction) that will not be operated under GO Transit may:

a) Install an automatic device that reduces the outward spillage of internal light; and

b) Ensure any rooftop architectural illumination is directed downward.

7 RESILIENCE

7.1 CLIMATE VULNERABILITY AND RISK ASSESSMENTS

7.1.1 OBJECTIVES

The objectives of this section are to understand the potential vulnerabilities of an asset so that Metrolinx's future infrastructure can anticipate, prevent, withstand, respond to, and recover from a climate related disruption or impact. This section aligns Metrolinx projects with the Federal Climate Lens.

7.1.2 REQUIREMENTS

All project locations with capital costs over $50 Million shall:

a) Undertake a preliminary climate risk and vulnerability assessment at no later than 30% design that identifies opportunities early in design to improve climate resiliency. The preliminary climate risk and vulnerability analysis can be predominantly qualitative. The preliminary climate risk and vulnerability analysis can be a review and update to the TPAP analysis undertaken in line with the MECP Guideline Considering Climate Change in the Environmental Assessment Process;

b) Perform a Climate Vulnerability Risk assessment using the PIEVC method established by Engineers Canada and conduct their assessment using the PIEVC Vulnerability Assessment templates and instructions found in section 7.1.5 (https://pievc.ca/), or ISO 14091, or equivalent with prior approval by Metrolinx. The PIEVC summary report shall be submitted no later than 60% design;

c) Address through the risk assessment, at a minimum, four critical changing climate parameters:

- Increase in extreme temperature
- Increase in the occurrence of extreme rainfall events
- Increase in the occurrence of freezing rain events
- Increase in the frequency of extreme wind events

Additional changing climate parameters can be found in Table 8.

d) Assess the impacts of climate change on both assets and operations;

e) Demonstrate how the project will adapt to high risks in alignment with the PIEVC Scoring Matrix in Table 7;

f) Provide options for adapting to medium risks in alignment with the PIEVC Scoring Matrix in Table 7;

g) Consider through the vulnerability assessment the anticipated lifespan of the project, and of its individual elements, calculated per section 7: Predicted Service Life of Components and Assemblies of CSA 478: Guideline on Durability in Buildings;

h) Include in the development of the vulnerability assessment, participation and/or review from key internal and external stakeholders including Metrolinx Operations and Maintenance, Engineering and Asset Management, and Transportation Policy and other departments, as follows:

1. Hold at least one workshop with key stakeholders to collect information on the severity of impacts. The workshop can be scoped based upon analysis from previous PIEVC reports deemed to be sufficient and applicable based on professional judgement; and
2. Prepare a report with a risk analysis of medium and high risk items with high level cost estimation of each adaptation option.

i) Use internationally recognized climate projections, and conservative scenarios such as RCP 8.5 (not lower emissions scenarios), if supplemental climate parameters and associated probabilities are to be developed.

7.1.3 OPTIONS

All project locations with capital costs over $50 Million may implement mitigation measures for medium risks.

7.1.4 REPORTING DIRECTION

The standard approach to risk assessment to climate impacts is a quantitative risk evaluation process that consists of:

a) A scale to describe the likelihood / probability of the risk arising (Table 5);

b) A scale to describe the level of consequence / severity of that risk, should it happen (Table 6);

c) A scale to assign a priority rating to each risk, given these two variables (Table 7); and

d) A relevant climatic analysis as provided in the PIEVC format in Table 8.

The 'Risks' identified are therefore related to the relationship between climatic events and the components of infrastructure. Risk is a measure of the probability of an event occurring multiplied by the impact (severity) of the event happening and can be used to quantify **vulnerability**. Risk can be mathematically illustrated as: R = P x Se

[R = Risk P = Probability of the event occurring Se = Severity of the event]

For each applicable infrastructure component found in Appendix B - Table 12, a risk probability score and severity level will be assigned which results in a priority rated risk score. Note that the infrastructure components in Appendix B - Table 12 shall be updated as appropriate to the project.

Table 5: PIEVC Probability Score

PIEVC Score	Probability of Occurrence	
0	<0.1%	<1 in 1,000
1	1%	1 in 100
2	5%	1 in 20
3	10%	1 in 10
4	20%	1 in 5
5	40%	1 in 2.5
6	70%	1 in 1.4
7	>99%	>1 in 1.01

Table 6: PIEVC Severity Score Factors

PIEVC Score	Severity characteristics
0	Negligible or Not Applicable
1	Very Low/Unlikely/Rare/Measurable Change
2	Low/Seldom/Marginal/Change in Serviceability
3	Occasional Loss of Some Capacity
4	Moderate Loss of Some Capacity
5	Likely Regular/Loss of Capacity and Loss of Some Function
6	Major/Likely/Critical Loss of Function
7	Extreme/Frequent/Continuous/Loss of Asset

Table 7: PIEVC Scoring Matrix

Severity								
7	0	7	14	21	28	35	42	49
6	0	6	12	18	24	30	36	42
5	0	5	10	15	20	25	30	35
4	0	4	8	12	16	20	24	28
3	0	3	6	9	12	15	18	21
2	0	2	4	6	8	10	12	14
1	0	1	2	3	4	5	6	7
0	0	0	0	0	0	0	0	0
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**

Probability

Special Case
Low Risk
Medium Risk
High Risk

Table 8: Metrolinx Climate Parameters List: Probability and Scores

Climate Parameter	Threshold	Annual Probability		Prob. Of Occurence for Period (2015-2050)	PIEVC Scoring		
		Historical	2050s		Annual: Historical	Annual: 2050s	Study Period (35 year)
Extreme Temperatures	40°C	~0.01 per year	1-7 days per year	~100%	1	7	7
	32°C	6.5 days per year	27.5 days per year	1	7	7	7
	-30°C	0.05 days per year	<0.01 days per year	<70%	2	0-1	5-6
	-23°C	1.1 days per year	0.1 days per year	1	7	3	7
Temperature Ranges	60°C in one year	0.1 days per year	<0.01 events per year	<90%	3	0-1	6
Reduced Visibility *(e.g. fog, blowing snow)*	400 m	49 hours per year, 15.1 days per year	strong trend ↓, stable recent period	1	7	6-7	7
	200 m	33 hours per year, 11.9 days per year	strong trend ↓, stable recent period	1	7	6-7	7
Frost Penetration	1.2 m or below	0.17 per year	Trend↓ but some conflicting factors	>90%	4	3	6-7
High Winds (Gusts)	90 km/h	2 per year	>2.5 per year	1	7	7	7
	120 km/h	0.05 days per year	Likely ↑	85% or higher	2	2	6-7
Tornadoes	EF1+	1-in-6,000	Unknown	~0.6%	0	0	0-1
Overland Flood/Heavy Rainfall	≥25 mm in 2 hour	~ 0.8 events per year	Very likely ↑	1	6	6	7
	≥60 mm in 2 hours	≤ 0.03 events or less per year	Very likely ↑	~70%	1-2	2	6
Freezing Rain	≥ 10 mm	~ 0.2 days per year	~ 0.3 days per year	~100%	4	4-5	7
	≥ 25 mm	0.06 days per year	>0.09 days per year	>95%	2	3	7
Snow	Blowing snow	7.8 days per year	Trends not significant to scoring	1	7	7	7
	≥ 20 cm in one day	0.1 days per year	Conflicting trends, likely remaining similar	>95%	3	3	6-7
Hail	"Gold ball" / 45 mm or larger	0.07 per year	Unknown	>90%	2-3	unknown	6
Horizontal Rain	Gusting 50km/h + >25 mm rain	1.8 days per year	Slight trend ↑	1	7	7	7
Lightning	Direct strikes	~ 0.3% per year	Likely ↑	>99%	1	unknown	3

7.2 DESIGN FOR FUTURE CLIMATE

7.2.1 OBJECTIVES

Opportunities and cost efficiencies in improving infrastructure resiliency are generally greater the earlier they are identified in the project life-cycle. The objective of this section is to understand the potential risks and vulnerabilities associated with climate change projections and to increase the **resilience** of Metrolinx buildings, services and assets over asset lifespans given climate projections and associated anticipated climate impacts.

7.2.2 REQUIREMENTS

All projects shall:

a) Provide designs that account for future climatic conditions over the anticipated lifespan of the project and its individual elements (i.e. account for at a minimum potential increases in rainfall intensity, temperature, windspeed, among others); and

b) Incorporate the following adaptation measures, where applicable:

1. The size of A/C units account for higher average heat tolerances;
2. Future proof roofs of conditioned spaces to accommodate larger A/C units;
3. All assets, especially glass doors, windows, waiting shelter, signage, and solar PV panels, shall ensure design is able to withstand higher extreme wind gusts (typically ≥ 120 km/hr);
4. All assets are designed to be resilient to freeze-thaw cycles;
5. Design communication systems to withstand higher wind gusts (typically ≥ 120 km/hr);
6. Installation of backflow preventers at connections to the municipal services network;
7. Installation of back-up (redundant or spare) sump pumps;
8. Installation of back-up power;
9. Installation of an early warning alarm system which notifies operation and maintenance staff when a cooling system is overloaded;
10. Other measures as appropriate to the climate vulnerabilities identified in 7.1; and
11. Durability per CSA S478.

7.3 SNOW AND ICE MANAGEMENT

7.3.1 OBJECTIVES

The objective of this section is to support through design effective snow and ice management during construction and operation, to maintain safe conditions, to reduce the impacts of salt use, and to minimize the impact of snow and ice accumulation.

7.3.2 REQUIREMENTS

All projects shall:

a) Design assets to minimize the likelihood of hazardous conditions arising from snow and ice accumulation including;

1. Slips, trips and falls; and
2. Falling snow and ice that has accumulated on structures.

All site projects proposing a minimum 0.5ha of new or reconstructed hardscape shall:

b) Develop a snow and ice management plan during design, and submit at no later than 60% design, that:

1. Identifies snow storage areas to be used during the operations phases, while supporting clear, barrier free access. Snow storage areas shall be away from public streets and other areas where motorist/pedestrian sight distances and continuous landscape screening are essential. Snow storage areas shall be sized to handle a volume of snow equivalent to a minimum of the 24-hour accumulation (as per the latest National Building Code of Canada) over the area required to be cleared;
2. Indicates the expected volume of snow to be cleared on an annual and daily basis based on the National Building Code of Canada climatic data;
3. Considers the access of snow ploughs and the impact snow storage and removal will have on the hardscape and landscape. For example, keep signage supports adjacent to, rather than in the path of travel, to minimize conflicts with snow removal equipment; and
4. Considers access to all areas which require regular clearing during winter months including sidewalks, entrances, staircases, parking spaces, ramps and roofs.

c) Prevent water from pooling or flowing through vehicular and pedestrian travel routes to the greatest extent possible, with a strategy for cold weather months included. Roof drains shall be directed away from vehicular or pedestrian travel routes; and

d) Minimize through design strategies the need for snow and ice management during operations. Recommended strategies include:

- proper location of snow storage;
- use of deciduous plants to reduce winter shading;
- snow melt systems;
- **permeable paving** (note that permeable hardscapes are less prone to ice accretion);
- minimal road grades at intersections; and
- rougher pavement.

7.3.3 GUIDANCE

Snow and ice management plans should identify snow storage areas during construction.

7.3.4 REPORTING DIRECTION

A template table of contents has been provided for informational purposes only and is intended to provide guidance. It is recommended that the Snow and Ice Management Plan follow a standardized format with the following sections:

- Executive Summary;
- Section 1: Climatic Information including the expected volume of snow expected on site;
- Section 2: Snow clearing strategy for site indicating areas that will be cleared and where snow will be stored;
- Section 3: Melt strategy for site indicating how snow and ice melt, including rain on snow and ice, will be managed to ensure the impact on operations will be minimized; and
- Section 4: Snow and ice safety strategy for site, indicating how the design prevents snow and ice build-up and falling in high traffic areas.

8 SUSTAINABILITY PLAN & REPORTING

8.1 SUSTAINABILITY PLAN

8.1.1 OBJECTIVES

The objective of the sustainability plan is to ensure that sustainability is considered at the appropriate stages through design to support project decision making, and to develop appropriate targets and metrics for reporting through construction.

8.1.2 REQUIREMENTS - PRELIMINARY SUSTAINABILITY POTENTIAL ANALYSIS

All project locations with a minimum capital cost of $50 Million shall submit a Preliminary Sustainability Potential Analysis at no later than 30% design, which shall:

a) Outline the sustainable design concept, including the functional and technical requirement;

b) Provide a preliminary analysis of opportunities and strategies to achieve a sustainable design, covering each section of this standard, as appropriate to a 30% design. A chart format is acceptable;

c) Provide a checklist and strategy for any sustainability certifications being pursued;

d) Provide a preliminary energy analysis per section 3.2.2(a); and

e) Provide a preliminary climate vulnerability and risk assessment per section 7.1.

8.1.3 REQUIREMENTS – DRAFT SUSTAINABILITY PLAN

All project locations with a minimum capital cost of $50 Million shall submit a draft Sustainability Plan at no later than 60% Design, which shall:

a) Provide an updated checklist and strategy for any sustainability certifications being pursued;

b) Provide details for meeting all applicable requirements of this standard;

c) Include life-cycle cost analysis per section 2.1;

d) Include LCA of embodied carbon per section 2.2;

e) Include the submission of all design phase reports and analysis that have not yet been submitted;

f) Provide sustainability goals, targets and metrics for construction (for projects with a capital cost of more than $50 Million); sustainability goals, targets and metrics shall be proposed to align with the Project Agreement or MAPP and Metrolinx Sustainability Plan; and

g) Provide the template for the construction sustainability report (for projects with a capital cost of more than $50 Million).

8.1.4 REQUIREMENTS – FINAL SUSTAINABILITY PLAN

All project locations with a minimum capital cost of $50 Million, shall submit a final Sustainability Plan at 90% or

100% Design, which shall update the draft Sustainability Plan.

8.2 CONSTRUCTION SUSTAINABILITY REPORTING

8.2.1 OBJECTIVES

The objectives of this section are to understand and reduce the impacts of projects on a broad range of sustainability factors through construction.

8.2.2 REQUIREMENTS

All project locations with a minimum capital cost of $50 Million, shall:

a) Produce a Construction Sustainability Report that:

1. Tracks and monitors sustainable practices during project delivery, reported at six-month intervals using at minimum the metrics outlined in Section 9.1.5, Table 9;
2. Identifies any targets not met, with a rationale as well as a recovery plan for the next year to get the project back on track to meet the target;
3. Provides any updates as required to the Sustainability Plan; and
4. Updated targets and metrics, if required.

b) Produce a Sustainability Substantial Completion Report that:

1. Summarizes the sustainability reporting results during construction using at a minimum the metrics outlined in Table 9; and
2. Provide copies of any available Environmental Product Declarations for project materials.

c) Establish targets for each metric in Table 9 that, at a minimum, support the achievement of the project sustainability goals and align with design standards. Targets shall include the following:

1. Description of the utilization and application of measurement parameters and monitoring methods; and
2. Metrics for evaluating the achievement of sustainable design targets throughout the project term.

d) Be prepared to provide Metrolinx with the supporting information (including data) behind each metric, upon request.

8.2.3 REPORTING DIRECTION

Construction sustainability reports shall be provided to Metrolinx on a biannual basis and include reports on the metrics outlined in Table 9.

Table 9: Construction sustainability reporting metrics

Activity	Reporting Category	Unit of Measure	Biannual Report	Substantial Completion Report
Construction Materials Imported to Site	Concrete	Tonnes		X
	Steel	Tonnes		X
	Soil/Aggregate/fill imported	Tonnes	X	X
	Aluminum	Tonnes		X
	Asphalt	Tonnes		X
	Wood	Tonnes & Percentage FSC Certified or equivalent		X
	Glass	Tonnes		X
	Other materials per section 2.2	Tonnes		X
	Soil/ Aggregate/fill exported	Tonnes	X	X
Transport & Fuels	Diesel consumed on site by construction activities	L	X	X
	Gasoline consumed on site by construction activities	L	X	X
	Trucking of soils/aggregate/fill (Import and Export)	km	X	X
Energy	Natural Gas	m^3	X	X
	Grid power	kWh	X	X
	Non-Grid Renewable Energy	kWh	X	X

Activity	Reporting Category	Unit of Measure	Biannual Report	Substantial Completion Report
Waste (excluding aggregate, fill and hazardous materials)	Recycled and composted	Tonnes	X	X
	Diversion Rate: [(Units of Recycling + Composting + Reused)/(Units of Recycling + Composting + Reused + Landfilled)] x100	%	X	X
	Reused Materials (on site)	Tonnes	X	X
	Landfilled	Tonnes	X	X
Landscape	Native plantings (separate by trees, shrubs, and plants)	Percentage native plants		X
	Disturbed Soils	volume or % of area of native soils protected from compaction during construction or restored		X
	Proportion of site & roof vegetated	%		X
Water	Water consumption during construction	L	X	X
	Percentage of landscaping planted with drought-tolerant species	%		X

9 DEFINITIONS

Term	Definition
BUG Rating	The Backlight, Uplight, and Glare rating is used to evaluate luminaire optical performance related to the light trespass, sky glow, and high angle brightness control.
Climate change	Refers to any change in climate over time, whether due to natural variability or as a result of human activity.
Cool Roof	A cool roof consists of roofing materials with a three year aged SRI of at least 64 for roofs with a slope less than 1:6, and a three year aged SRI of at least 15 for roofs with a slope greater than 1:6.
Correlated Color Temperature (CCT)	A specification of the color appearance of the light emitted by a lamp, relating its color to the color of light from a reference source when heated to a particular temperature, measured in degrees Kelvin (K).
Criteria Air Contaminants	Criteria Air Contaminants are emissions of seven air pollutants tracked by Environment Canada that affect our health and contribute to air pollution problems such as ground level ozone, haze, and acid rain: • total particulate matter (TPM) • particulate matter with a diameter less than or equal to 10 microns (PM_{10}) • particulate matter with a diameter less than or equal to 2.5 microns ($PM_{2.5}$) • sulphur oxides (SO_x) • nitrogen oxides (NO_x) • volatile organic compounds (VOC) • carbon monoxide (CO) Source: Environment Canada. National Pollutant Release Inventory. http://www.ec.gc.ca/inrp-npri/default.asp?lang=En&xml=AFF8EAF0-20B4-4B45-9B0E-DB079092B825
Energy Use Intensity (EUI)	The total amount of energy consumed in a building per floor area net of on-site renewable energy generated (expressed as kWh/m^2/year). Also known at Total Energy Use Intensity (TEUI) in TGS.

Term	Definition
Environmental Footprint	The effect that a person, company, activity, etc. has on the environment; for example the amount of natural resources that they use and the amount of harmful gases that they produce.
Greenhouse gas (GHG)	Gases that trap the sun's warmth within the atmosphere, causing a greenhouse effect, such as water vapour (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), and ozone (O_3).
Greenhouse Gas Intensity (GHGI)	The total amount of GHGs from a building's energy use (expressed as $kg/m^2/year$)
Greywater	Untreated building waste water which has not come into contact without fecal contamination.
Heat island	An urban area characterised by ambient temperatures higher than those of the surrounding non-urban area. The cause is a higher absorption of solar energy by materials of the urban fabric such as asphalt.
Intensity-Duration-Frequency curve (IDF Curve)	A graphical representation of the probability that a given average rainfall intensity and duration will occur.
Leadership in Energy and Environmental Design (LEED®)	An internationally recognized green building certification system, providing third-party verification that a building or community was designed and built using strategies aimed at improving performance.
Life-cycle Assessment (LCA)	A technique to assess environmental impacts associated with all the stages of a product's life from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling.
Life-cycle Cost Analysis	A method for assessing the total cost of facility ownership. It is a tool that can be used to determine the most cost-effective option among different competing alternatives to purchase, own, operate, maintain and, finally, dispose of an object or process.
Low Impact Development (LID)	Is applied to minimize runoff at source and mimic the natural water balance by focusing on practices that promote increased evapotranspiration, infiltration and groundwater recharge, and lower surface runoff volumes and flow rates.

Term	Definition
Major Storm	That storm drainage system which carries the total runoff of the drainage system less the runoff carried by the minor system. The major system will function whether or not it has been planned and designed, and whether or not developments are situated wisely with respect to it. The Major Drainage System usually includes many features such as streets, gullies, and major drainage channels.
Minor Storm	That storm drainage system which is frequently used for collecting, transporting, and disposing of snowmelt, miscellaneous minor flows, and storm runoff up to the capacity of the system. The minor system may include many features ranging from curbs and gutters to storm sewer pipes and open drainage ways. The capacity should be equal to the maximum rate of runoff to be expected from the minor design storm which may have a frequency of occurrence of one in 10 years for industrial Sites.
Net present value (NPV)	The difference between the present value of cash inflows and the present value of cash outflows over a period of time.
On Corridor / Off corridor	On corridor or “Oncorr” refers to the Metrolinx main rail network and associated infrastructure such as rail bridges, signaling systems, culverts, among other infrastructure. Off corridor or “Offcorr” refers to the Metrolinx infrastructure that supports the rail network such as stations, bus terminals, other bus infrastructure, maintenance facilities, and pedestrian bridges among other infrastructure.
Permeable Paving	A permeable hardscape that allows storm water infiltration through the surface into a stone reservoir. Permeable paving includes: • permeable interlocking concrete pavers • plastic or concrete grid systems • pervious concrete • pervious asphalt

Term	Definition
Resilience	The ability of Metrolinx, its infrastructure assets, and the component parts of its regional transit system to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions.
Solar Reflectance Index (SRI)	Measures of the constructed surface's ability to stay cool in the sun by reflecting solar radiation and emitting thermal radiation.
Supplementary Cementitious Materials (SCMs)	Contribute to the properties of hardened concrete through hydraulic or pozzolanic activity. Typical examples are fly ashes, slag cement (ground, granulated blast-furnace slag), and silica fume. These can be used individually with portland or blended cement or in different combinations. Supplementary cementitious materials are often added to concrete to make concrete mixtures more economical, reduce permeability, increase strength, or influence other concrete properties.
Thermal Energy Demand Intensity (TEDI)	The annual heat loss from building's envelope, net of passive heat gains and losses (expressed as kWh/m^2/year).
Thermal Bridge	A thermal bridge, also called a cold bridge, heat bridge, or thermal bypass, is an area or component of an object which has higher thermal conductivity than the surrounding materials, creating a path of least resistance for heat transfer.
Total Suspended Solids (TSS)	The dry-weight of suspended particles that are not dissolved, in a sample of water that can be trapped by a filter that is analyzed using a filtration apparatus.
Vulnerability	The propensity or predisposition to be adversely affected. Vulnerability to climate change is the degree to which Metrolinx infrastructure assets, our passengers, employees and contractors, and the region within which we provide transit services, are susceptible to, and unable to cope with, the adverse impacts of climate change.

10 ABBREVIATIONS

Abbreviation	Definition
AFP	Alternate Finance and Procurement
BIPV	Building Integrated Photovoltaics
BUG Rating	Backlight, Uplight, Glare Rating
CAC	Criteria Air Contaminant
CaGBC	Canada Green Building Council
CCT	Correlated Color Temperature
CEN	European Committee for Standardization
CH_4	Methane
CM	Construction Management
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
CSA	Canadian Standards Association
DB	Design Build
DBB	Design Bid Build
DSF	Double-skin Façade
EUI	Energy Use Intensity
GFA	Gross Floor Area
GHG	Greenhouse Gases

Abbreviation	Definition
GHGI	Greenhouse Gas Intensity
GWP	Global Warming Potential
HAP	Hourly Analysis Program
HFCs	Hydrofluorocarbons
HVA	Highly Vulnerable Aquafor
HVAC	Heating, Ventilation, and Air Cooling
IDF Curve	Intensity-Duration-Frequency Curve
IESNA	Illuminating Engineering Society of North America
ISO	International Organization for standardization
LCA	Life-Cycle Assessment
LCC	Life-Cycle Costs
LEED	Leadership in Energy and Environmental Design
LID	Low Impact Development
LPD	Lighting Power Density
MAPPs	Metrolinx Asset Protection Plans
N_2O	Nitrous Oxide
NF_3	Nitrogen Trifluoride

Abbreviation	Definition
NPV	Net Present Value
NRCan	Natural Resources Canada
O & M	Operations and Maintenance
OBC	Ontario Building Code
OGS	Oil Grit Separator
OnCorr	On Corridor
PAs	Project Agreement
PFCs	Perfluorocarbons
PICP	Permeable Interlocking Concrete Pavers
PIEVC	Public Infrastructure Engineering Vulnerability Committee
PV	Photo Voltaic
PV	Present Value
RCP	Representative Concentration Pathway
SCM	Supplementary Cementitious Materials
SF_6	Sulphur Hexafluoride
SGRA	Significant Groundwater Recharge Area
SOGR	State of Good Repair

Abbreviation	Definition
SRI	Solar Reflectance Index
TEDI	Thermal Energy Demand Intensity
TGS	Toronto Green Standard
TSS	Total Suspended Solids
VSD	Variable Speed Drive
WHPA	Wellhead Protection Areas
WLC	Whole Life Costs

11 APPENDIX A - APPLICABILITY MATRIX

Table 10: Applicability Matrix

	PROJECT CATEGORIZARION					
Section	**New & Reconstructed Buildings with GFA >100m² Actively Heated & Cooled**	**Expansion to Existing Buildings**	**New & Reconstructed Buildings with GFA >100m² Actively Heated & Cooled**	**Site (Non-Building)**	**SOGR**	**Other**
Life-Cycle Cost	Requirements Guidance	Requirements Guidance	Requirements Guidance	Requirements Guidance	Requirements Guidance	Min. capital cost $30Mil per site
Life-Cycle Assessment (Embodied Carbon)	Requirements Guidance	Requirements Guidance	Requirements Guidance	Requirements Guidance	Requirements Guidance	Min. capital cost $30Mil per site with new building or pavement
Material Life-Cycle Impacts	Requirements Guidelines	Requirements Guidelines	Requirements Guidelines	Requirements Guidelines	Requirements Guidelines	Min. GFA for heated/ cooled spaces. Partly excludes GO Transit projects
Building Energy and Carbon Performance	Requirements Options	No	No	No	No	Min. GFA for heated/ cooled spaces
Energy Simulations and Modelling	Requirements Guidance Options	No	Requirements Guidance Options	No	No	

	PROJECT CATEGORIZARION					
Section	**New & Reconstructed Buildings with GFA >100m² Actively Heated & Cooled**	**Expansion to Existing Buildings**	**New & Reconstructed Buildings with GFA >100m² Actively Heated & Cooled**	**Site (Non-Building)**	**SOGR**	**Other**
Energy Efficient Design – Building Envelope	Requirements	Guidance	Guidance	No	No	
Energy Efficient Design –Mechanical System	Guidance Options	No	Guidance Options	No	No	Excludes GO Transit projects
Energy Efficient Design – Electrical Systems – Energy Automation and Control	Requirements	No	No	No	No	Excludes GO Transit projects
Energy Efficient Design – Electrical Systems – Energy Metering and Monitoring	Requirements	No	No	No	No	Excludes GO Transit projects
Energy Efficient Design – Electrical Systems – Lighting	Requirements	Requirements	Requirements	Requirements	Requirements	Excludes GO Transit projects
Energy Efficient Design – Electrical Systems – General	Requirements	Requirements	Requirements	No	No	Excludes GO Transit projects
Solar PV Renewable Energy	Requirements	Requirements	Requirements	No	No	See s.3.4.2(a)

	PROJECT CATEGORIZARION					
Section	**New & Reconstructed Buildings with GFA >100m² Actively Heated & Cooled**	**Expansion to Existing Buildings**	**New & Reconstructed Buildings with GFA >100m² Actively Heated & Cooled**	**Site (Non-Building)**	**SOGR**	**Other**
Heat Island Mitigation	Requirements	Requirements	Requirements	Requirements Options	No	If non-road plus roof area >0.25ha
Water Modelling, Metering and Monitoring	Requirements Options	Requirements Options	Requirements Options	No	No	Non-GO Transit assets with operational water consumption
Water Efficient Design	Requirements Guidance	Requirements Guidance	Requirements Guidance	Scope Dependent	No	Operational water consumption
Storm Water Performance Criteria	Requirements Guidance	Requirements Guidance	Requirements Guidance	Requirements Guidance	No	SWM report
Low Impact Development Strategies	Requirements Guidance Options	Requirements Guidance Options	Requirements Guidance Options	Requirements Guidance Options	Requirements Guidance Options	LID practices are proposed
Soil Management	No	No	No	Requirements Guidance	Requirements Guidance	Vegetated ground LIDs or >100m³ of disturbed native soil for planting

	PROJECT CATEGORIZARION					
Section	**New & Reconstructed Buildings with GFA >100m² Actively Heated & Cooled**	**Expansion to Existing Buildings**	**New & Reconstructed Buildings with GFA >100m² Actively Heated & Cooled**	**Site (Non-Building)**	**SOGR**	**Other**
Bird Friendly Design	Requirements Guidance	Requirements Guidance	Requirements Guidance	No	Requirements Guidance	Glazing within 12m of the ground or ground level ventilation
Light Pollution Reduction	Requirements Guidance	Requirements Guidance	Requirements Guidance	Requirements Guidance	Requirements Guidance	Non-GO Transit assets only proposing exterior lights
Climate Vulnerability and Risk Assessment	Requirements Guidance	Requirements Guidance	Requirements Guidance	Requirements Guidance	Requirements Guidance	Min. capital cost $50Mil per site
Design for Future Climate	Requirements Guidance	Requirements Guidance	Requirements Guidance	Requirements Guidance	Requirements Guidance	
Snow and Ice Management	Requirements Guidance	Requirements Guidance	Requirements Guidance	Requirements Guidance	Requirements Guidance	minimum 0.5ha of new or reconstructed hardscape
Sustainability Plan	Requirements Guidance	Requirements Guidance	Requirements Guidance	Requirements Guidance	Requirements Guidance	Min. capital cost $50Mil per site
Construction Sustainability Reporting	Requirements	Requirements	Requirements	Requirements	Requirements	Min. capital cost $50Mil per site

12 APPENDIX B - TEMPLATES

Table 11: Life-Cycle Cost Template

Level 1 Major Group Elements	Level 2 Group Elements	Level 3 Individual Elements	Life-Cycle Information		Life-Cycle Costs (CAD)							
			Estimated Design Life (Years)	Source(s)	Initial Construction [A]	Year 1	Year 2	Year 3	…	Year X (End of Evaluation Period)	Total Operating Period Cost Year 1 to Year X (Discounted) [B]	Total Cost [C = A+B]
	Life-Cycle Costs (inclusive of construction, maintenance, and end of life costs for the life of the project)											
A. SUBSTRUCTURE	A.10 Foundations	A1010 Standard Foundations										
		A2020 Special Foundations										
		A1030 Slab on Grade										
	A.20 Basement Construction	A2010 Basement Excavation										
		A2020 Basement Walls										

Level 1 Major Group Elements	Level 2 Group Elements	Level 3 Individual Elements	Life-Cycle Information		Life-Cycle Costs (CAD)							
			Estimated Design Life (Years)	Source(s)	Initial Construction [A]	Year 1	Year 2	Year 3	...	Year X (End of Evaluation Period)	Total Operating Period Cost Year 1 to Year X (Discounted) [B]	Total Cost [C = A+B]
B. SHELL	B.10 Superstructure	B1010 Floor Construction										
		B1010 Roof Construction										
	B.20 Exterior Closure	B2010 Exterior Walls										
		B2020 Exterior Windows										
		B2030 Exterior Doors										
	B.30 Roofing	B3010 Roof Coverings										
		B3020 Roof Openings										

Level 1 Major Group Elements	Level 2 Group Elements	Level 3 Individual Elements	Life-Cycle Information		Life-Cycle Costs (CAD)							
			Estimated Design Life (Years)	Source(s)	Initial Construction [A]	Year 1	Year 2	Year 3	...	Year X (End of Evaluation Period)	Total Operating Period Cost Year 1 to Year X (Discounted) [B]	Total Cost [C = A+B]
C. INTERIORS	C.10 Interior Construction	C1010 Partitions										
		C1020 Interior Doors										
		C1030 Fittings										
	C.20 Staircases	C2010 Stair Construction										
		C2020 Stair Finishes										
	C.30 Interior Finishes	C3010 Wall Finishes										
		C3020 Floor Finishes										
		C3030 Ceiling Finishes										

Level 1 Major Group Elements	Level 2 Group Elements	Level 3 Individual Elements	Life-Cycle Information		Life-Cycle Costs (CAD)							
			Estimated Design Life (Years)	Source(s)	Initial Construction [A]	Year 1	Year 2	Year 3	…	Year X (End of Evaluation Period)	Total Operating Period Cost Year 1 to Year X (Discounted) [B]	Total Cost [C = A+B]
D. SERVICES	D.10 Conveying Systems	D1010 Elevators & Lifts										
		D1020 Elevators & Moving Walks										
		D1090 Other Conveying Systems										
	D.20 Plumbing	D2010 Plumbing Fixtures										
		D2020 Domestic Water Distribution										
		D2030 Sanitary Waste										
		D2040 Rain Water Drainage										
		D2090 Other Plumbing System										

Level 1 Major Group Elements	Level 2 Group Elements	Level 3 Individual Elements	Life-Cycle Information		Life-Cycle Costs (CAD)							
			Estimated Design Life (Years)	Source(s)	Initial Construction [A]	Year 1	Year 2	Year 3	…	Year X (End of Evaluation Period)	Total Operating Period Cost Year 1 to Year X (Discounted) [B]	Total Cost [C = A+B]
	D.30 HVAC	D3010 Energy Supply										
		D3020 Heat Generating Systems										
		D3030 Cooling Generation Systems										
		D3040 Distribution Systems										
		D3050 Terminal & Package Units										
		D3060 Controls & Instrumentation										
		D3070 Systems Testing & Balance										
		D3090 Other HVAC Systems & Equipment										

Level 1 Major Group Elements	Level 2 Group Elements	Level 3 Individual Elements	Life-Cycle Information		Life-Cycle Costs (CAD)							
			Estimated Design Life (Years)	Source(s)	Initial Construction [A]	Year 1	Year 2	Year 3	…	Year X (End of Evaluation Period)	Total Operating Period Cost Year 1 to Year X (Discounted) [B]	Total Cost [C = A+B]
	D.40 Fire Protection	D4010 Sprinklers										
		D4020 Standpipes										
		D4030 Fire Protection Systems										
		D4090 Other Fire Protection Systems										
	D.50 Electrical	D5010 Electrical Service & Distribution										
		D5020 Lighting & Branch Wiring										
		D5030 Communications & Security										
		D5090 Other Electrical Systems										

Level 1 Major Group Elements	Level 2 Group Elements	Level 3 Individual Elements	Life-Cycle Information		Life-Cycle Costs (CAD)							
			Estimated Design Life (Years)	Source(s)	Initial Construction [A]	Year 1	Year 2	Year 3	…	Year X (End of Evaluation Period)	Total Operating Period Cost Year 1 to Year X (Discounted) [B]	Total Cost [C = A+B]
	D.60 Electronic Security Systems	(as required)										
E. EQUIPMENT & FURNISHINGS	E.10 Equipment	E1010 Commercial Equipment										
		E1020 Institutional Equipment										
		E1030 Vehicular Equipment										
		E1090 Other Equipment										
	E.20 Furnishings	E2010 Fixed Furnishings										
		E2020 Movable Furnishings										

Level 1 Major Group Elements	Level 2 Group Elements	Level 3 Individual Elements	Life-Cycle Information		Life-Cycle Costs (CAD)							
			Estimated Design Life (Years)	Source(s)	Initial Construction [A]	Year 1	Year 2	Year 3	...	Year X (End of Evaluation Period)	Total Operating Period Cost Year 1 to Year X (Discounted) [B]	Total Cost [C = A+B]
F. SPECIAL CONSTRUCTION & DEMOLITION	F.10 Special Construction	F1010 Special Structures										
		F1020 Integrated Construction										
		F1030 Special Construction Systems										
		F1040 Special Facilities										
		F1050 Special Controls & Instrumentation										
G. SITE PREPARATION	G.10 Site Preparation	Earthworks										
		Landscaping										
		Other components as required										

Level 1 Major Group Elements	Level 2 Group Elements	Level 3 Individual Elements	Life-Cycle Information		Life-Cycle Costs (CAD)							
			Estimated Design Life (Years)	Source(s)	Initial Construction [A]	Year 1	Year 2	Year 3	…	Year X (End of Evaluation Period)	Total Operating Period Cost Year 1 to Year X (Discounted) [B]	Total Cost [C = A+B]
Other Project Specific Elements as defined by Metrolinx.												
	Operation Costs (for the whole design life of the project exclusive of the construction period)											
Cleaning			N/A	N/A	N/A							
Landscaping	Snow clearance Leaf clearance		N/A	N/A	N/A							
Security			N/A	N/A	N/A							
Other operating costs as defined by Metrolinx.			N/A	N/A	N/A							

Level 1 Major Group Elements	Level 2 Group Elements	Level 3 Individual Elements	Life-Cycle Information		Life-Cycle Costs (CAD)							
			Estimated Design Life (Years)	Source(s)	Initial Construction [A]	Year 1	Year 2	Year 3	…	Year X (End of Evaluation Period)	Total Operating Period Cost Year 1 to Year X (Discounted) [B]	Total Cost [C = A+B]
	Consumption Costs (for the whole design life of the project exclusive of the construction period)											
Energy	Electricity Gas		N/A	N/A	N/A							
Water	Potable Water		N/A	N/A	N/A							
Other consumption costs as defined by Metrolinx.												

Table 12: PIEVC vulnerability risk assessment evaluation template

Infrastructure Components		Structural Design	Functionality	Serviceability	Operations, Maintenance	Emergency Response	Liability Considerations	Policy Considerations	Socio-economic Effects	Public Relations	Watershed, Surface Water & Groundwater	Other Environmental Effects
		Mark Relevant Responses with ✓										
	Roofs											
1	Main Building											
2	Roof Canopies											
	Walls											
3	Solid											
4	Glass											
5	Electrical (power, lighting)											
6	Mechanical (elevator, sprinkler system)											
7	Communications											
	Site											
8	Parking Lots											
9	Sidewalks											
10	Platform											
11	Retaining Walls											
12	Tunnels											
13	Services/Utilities											
14	Floors and building content											
XX	Additional component to be added as required.											

Infrastructure Components		High Temperature								High wind/Downburst								Heavy Rain				Freezing Rain			
		Daily Temp ≥ 40°C				Daily Temp ≥ 32°C				Gusts > 90 km/h				Gusts > 120 km/h				2-hour Rainfall > 60 mm				Ice Accretion > 25 mm			
		Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R
	Roofs																								
1	Main Building																								
2	Roof Canopies																								
	Walls																								
3	Solid																								
4	Glass																								
5	Electrical (power, lighting)																								
6	Mechanical (elevator, sprinkler system)																								
7	Communications																								
	Site																								
8	Parking Lots																								
9	Sidewalks																								
10	Platform																								
11	Retaining Walls																								
12	Tunnels																								
13	Services/Utilities																								
14	Floors and building content																								
XX	Additional component to be added as required.																								

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