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EVALUATION PROGRAM

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Smart Blue Roof Systems:

An Innovative Green Infrastructure Approach to Climate Change Adaptation

Presented by: *James Cowan, Technician*
Samantha Pelayo, Coordinator
Rohan Hakimi, Engineer

October 13th, 2022

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The water component of STEP is a collaborative of:

Lake Simcoe Region conservation authority

Credit Valley Conservation inspired by nature

Toronto and Region Conservation Authority

Overview

STEP is a multi-agency initiative developed to support broader implementation of sustainable technologies and practices within a Canadian context.

The water component of STEP is a conservation authority collaborative. Current partners are:

Lake Simcoe Region conservation authority

Credit Valley Conservation inspired by nature

Toronto and Region Conservation Authority

Our key areas of focus are:

- Low Impact Development
- Erosion and Sediment Control
- Road Salt Management
- Natural Features Restoration

Outline

- Background
- Smart Blue Roof Feasibility Study
- Intact Funded Implementation Study
- Design and Permitting Overview
- Construction to date
- Questions and Discussion

Smart Blue Roof Study

Region of Peel
Working for you

MISSISSAUGA

FCM
FEDERATION OF CANADIAN MUNICIPALITIES
FÉDÉRATION CANADIENNE DES MUNICIPALITÉS

[intact]

GTAA
PARTNERS IN PROJECT GREEN

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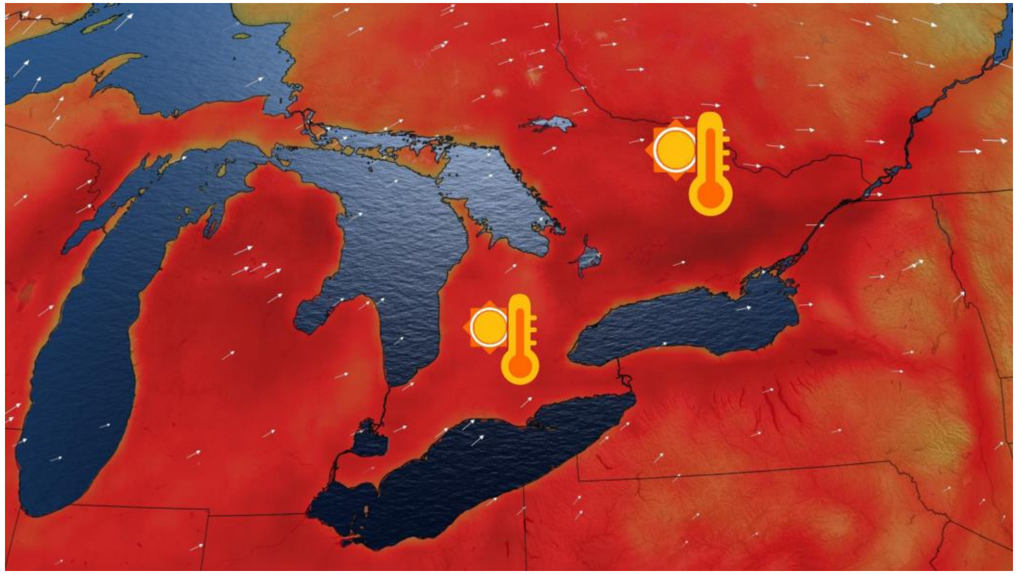
ENVIRO-STEWARDS

Background

Resilience against Climate Change



ICI Sector Stormwater Management

Industrial

Commercial

Institutional

Parking lots

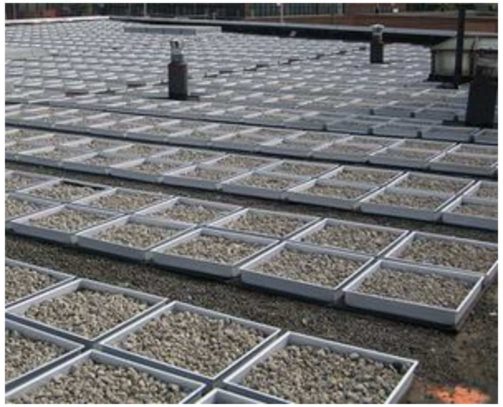
Rooftops

IMPERVIOUSNESS

The Evolution of Rooftop Stormwater Management

Conventional Flat Roof

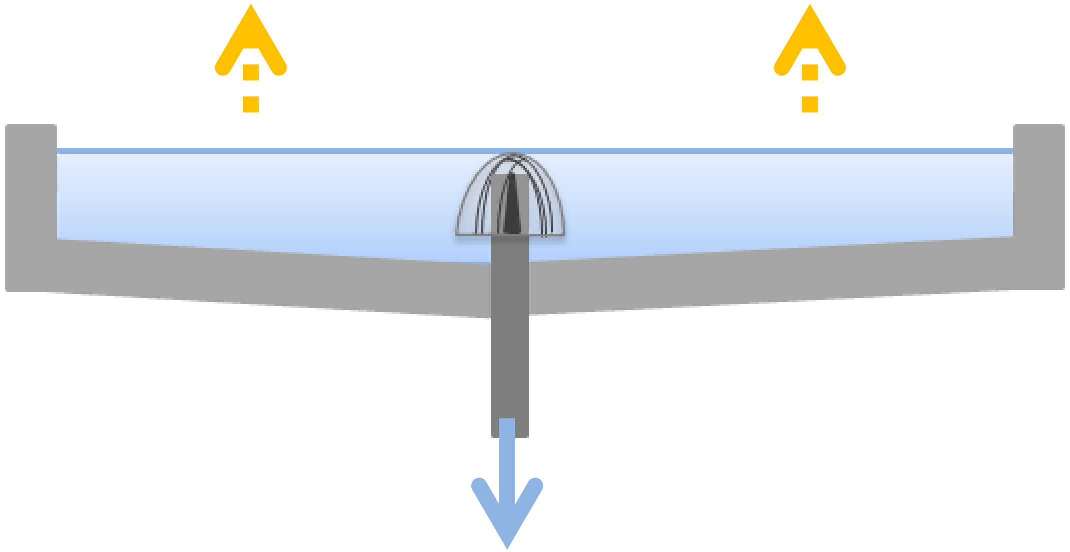
Green Roof



Blue Roof

Defining Blue Roofs

- Temporary detention of rainwater on flat, low-sloped roofs
  - System stores water for reuse and/or slowly releases stormwater
  - Evaporative cooling benefit in summer months



Compare Active vs. Passive Blue Roofs

Active

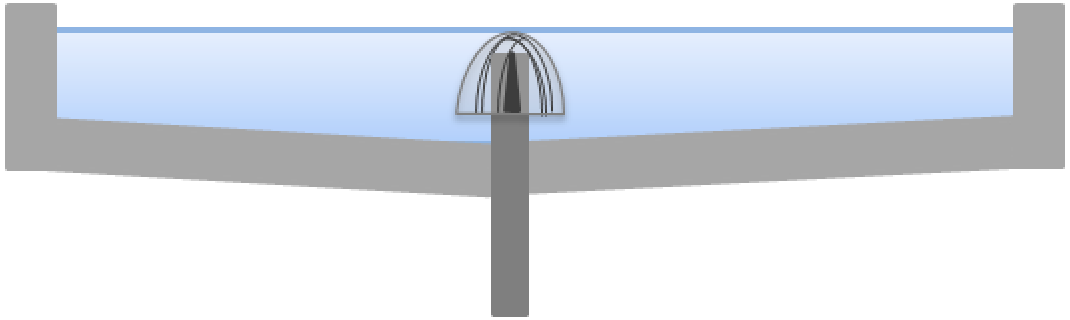
- Valve configuration and controller used to regulate roof discharge
- Controller programmed to optimize release of ponded water
- “Smart” system approach

Passive

- Use of static hydraulic structures such as weirs, drains, orifice plates to regulate the release of rainwater from a rooftop

Coupling Smart Blue Roof Systems

Blue Roof



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Rainwater Harvesting Tank

Enhanced Grass Swale

Subsurface Chambers

Feasibility Study

Smart Blue Roof Systems for the ICI Sector for Flood and Drought Resilience and Adaptation

Project Page

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Investigating the Technical and Financial Feasibility of a Smart Blue Roof

Credit Valley Conservation's (CVC) main office has a large, flat roof, making it an ideal place for STEP to investigate the feasibility of smart blue roof systems for stormwater management. While a large body of research has demonstrated the significant water management benefits of green roofs, this study will consider the potential of blue roof technology as a viable and cost-effective alternative. Blue roofs detain stormwater, releasing it slowly after rainfall events, allowing it to pond and evaporate, or in some cases storing it for non-potable reuse.

Initiated in early 2018 with the support of the Region of Peel and the Federation of Canadian Municipalities (FCM), this study investigated the possibility of retrofitting CVC's existing 'Building A' roof with a smart blue roof, with real-time controls. The intent of the system is to detain stormwater on the roof over an extended period of time, thereby reducing peak flows, promoting evaporation, and ultimately helping to build capacity and resiliency in Mississauga's municipal stormwater system.

The project investigated the feasibility of designing and constructing a blue roof integrated with "Internet of Things" technology – a system of sensors and real-time controls – for managing the flow of water from the roof to CVC's existing rainwater harvesting tank for indoor and outdoor non-potable use. The system's conceptual design is intended to maximize the potential benefits of blue roofs, including water and energy savings associated with rainwater reuse, reduced peak flows to storm sewer systems, and potential mitigation of the urban heat island effect.

Downloads

Final report (draft)
8 MB PDF

Literature Review
10 MB PDF

Interested in learning more?

» FCM funding announcement

» About blue roofs

» LID Stormwater Management Planning and Design Wiki: Blue Roofs

Link: https://sustainabletechnologies.ca

CVC Head Office as a Template

Thinking Outside the Tank

- Currently the RWH tank storage is equal to 7 mm in rooftop storage.

- The CVC office roof has the capacity to store 130 mm of water depth.

Structural Capacity of Roof

Table 2 Example of snow and rain load

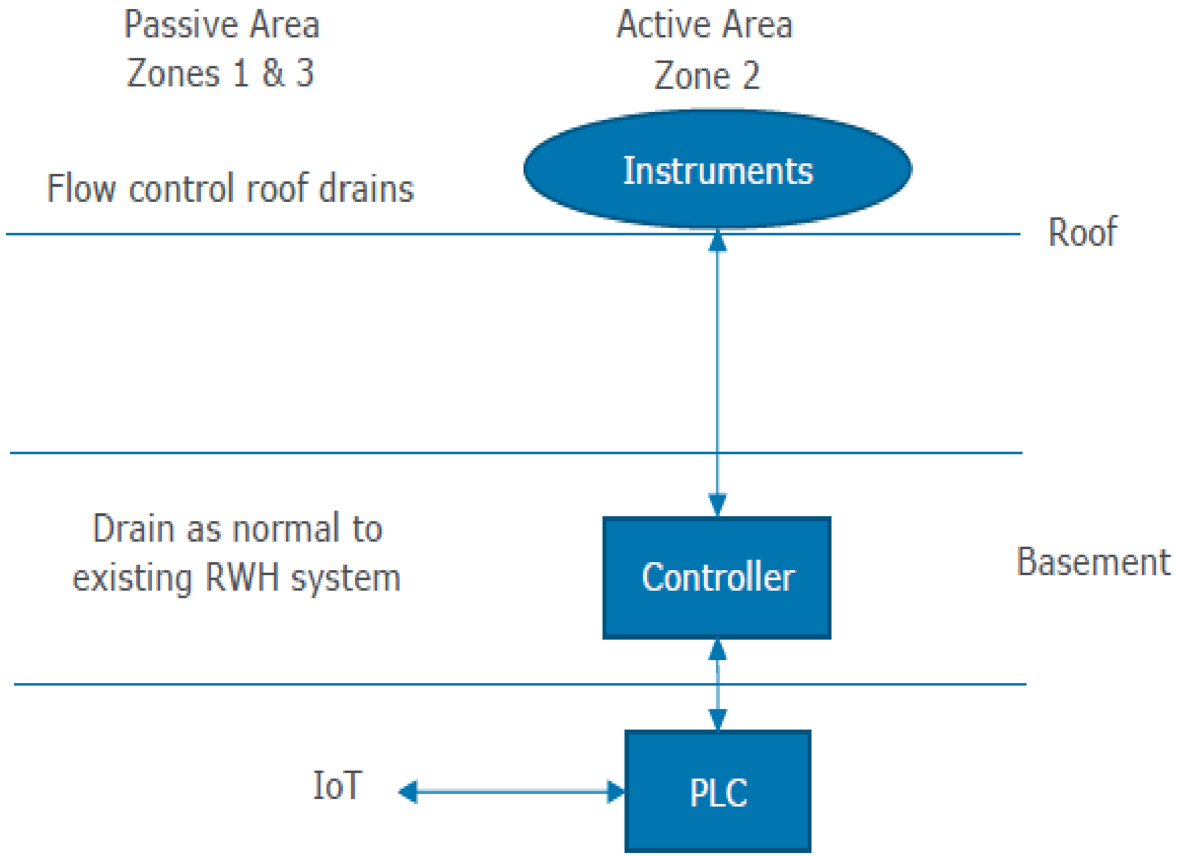
Location	Snow		Rain	
	(kPa)	(mm of water)	(kPa)	(mm of water)
Mississauga	1.28	130	1.11	113
Toronto	1.12	114	0.95	97

Water specific weight: γ = 9.805kN/m3 at 0°C,

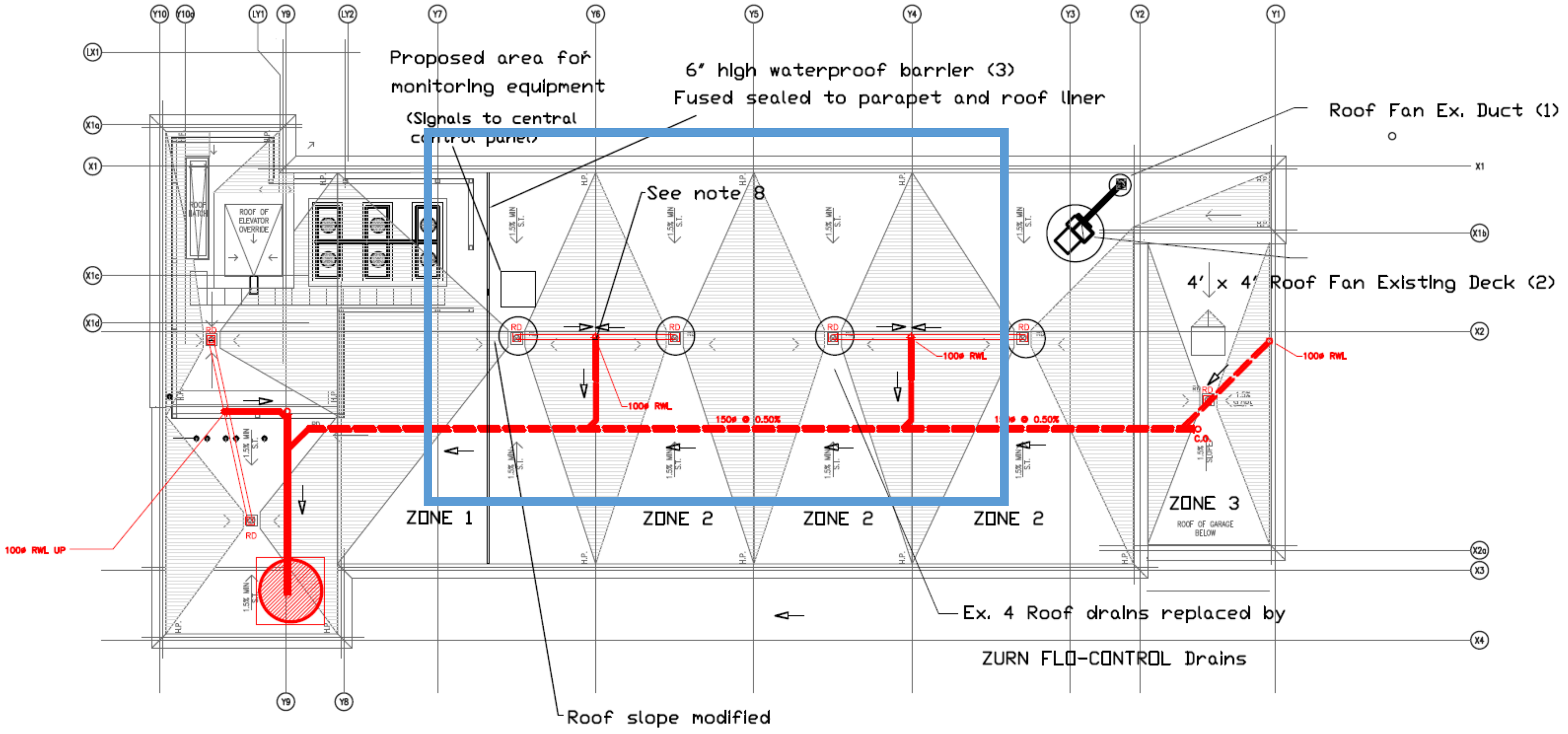
Across the entire surface. With a sloped roof, the depth varies.

Building code max depth at any given point = 150mm

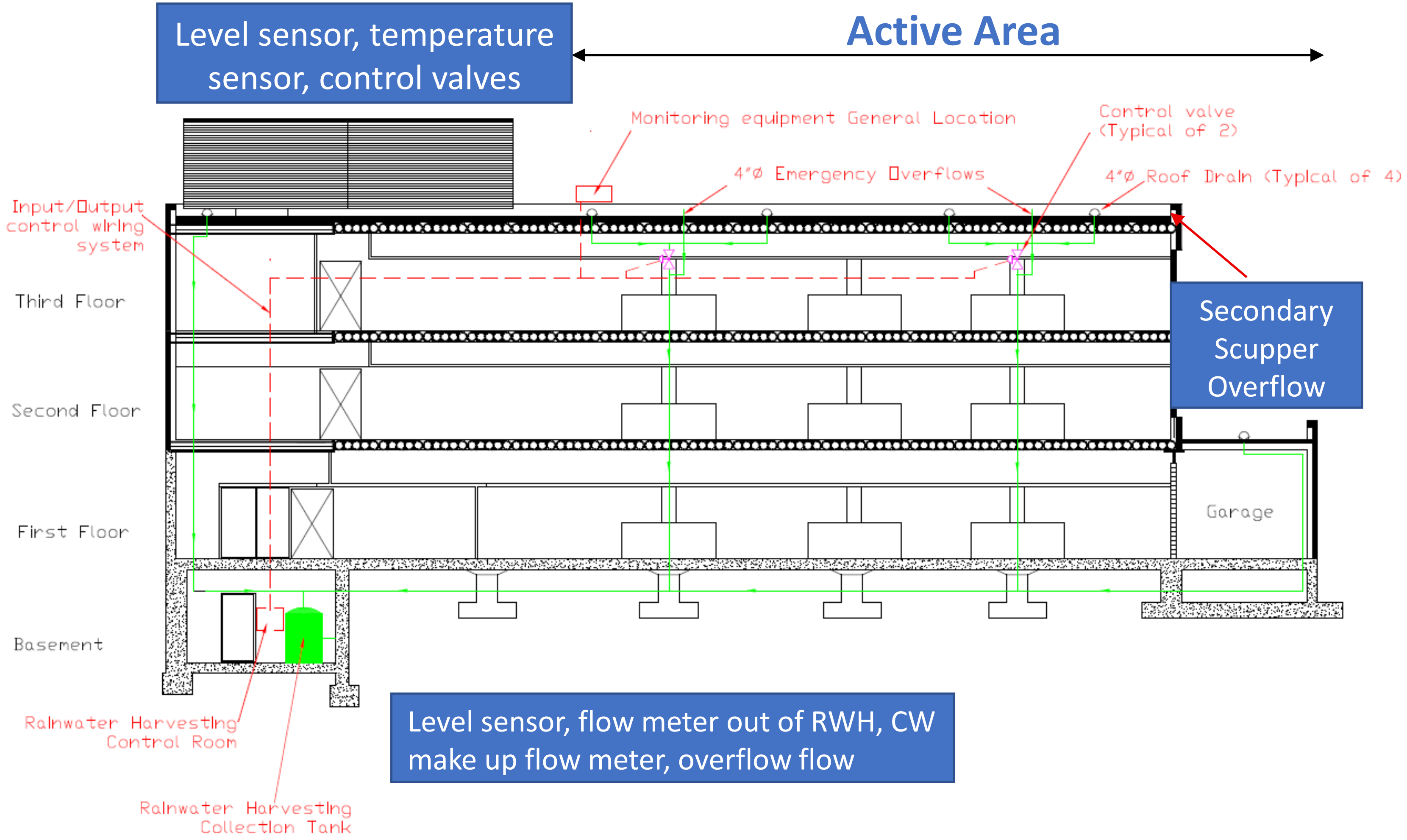
Schematic of the Smart Blue Roof and RWH System



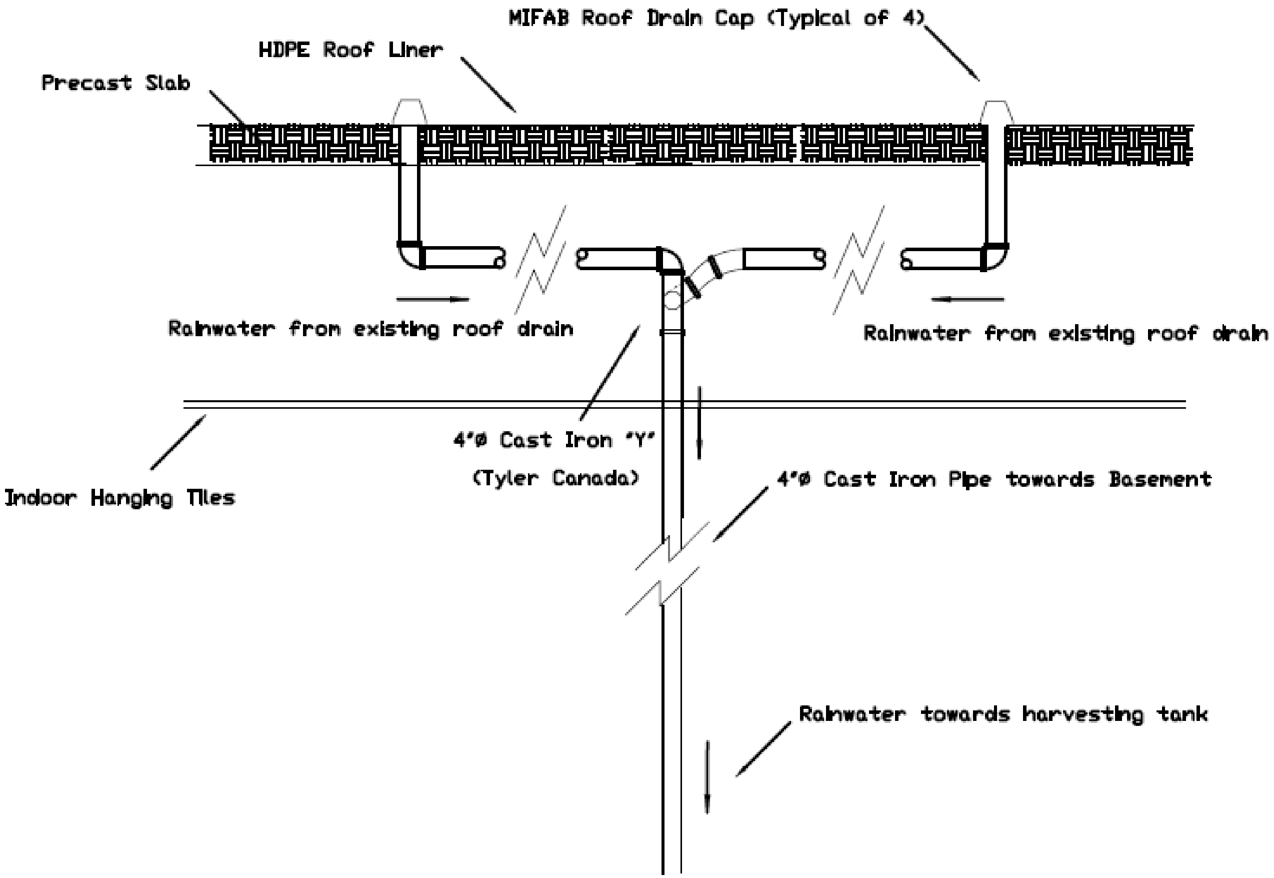
Proposed Rooftop



Proposed Building Cross-Section



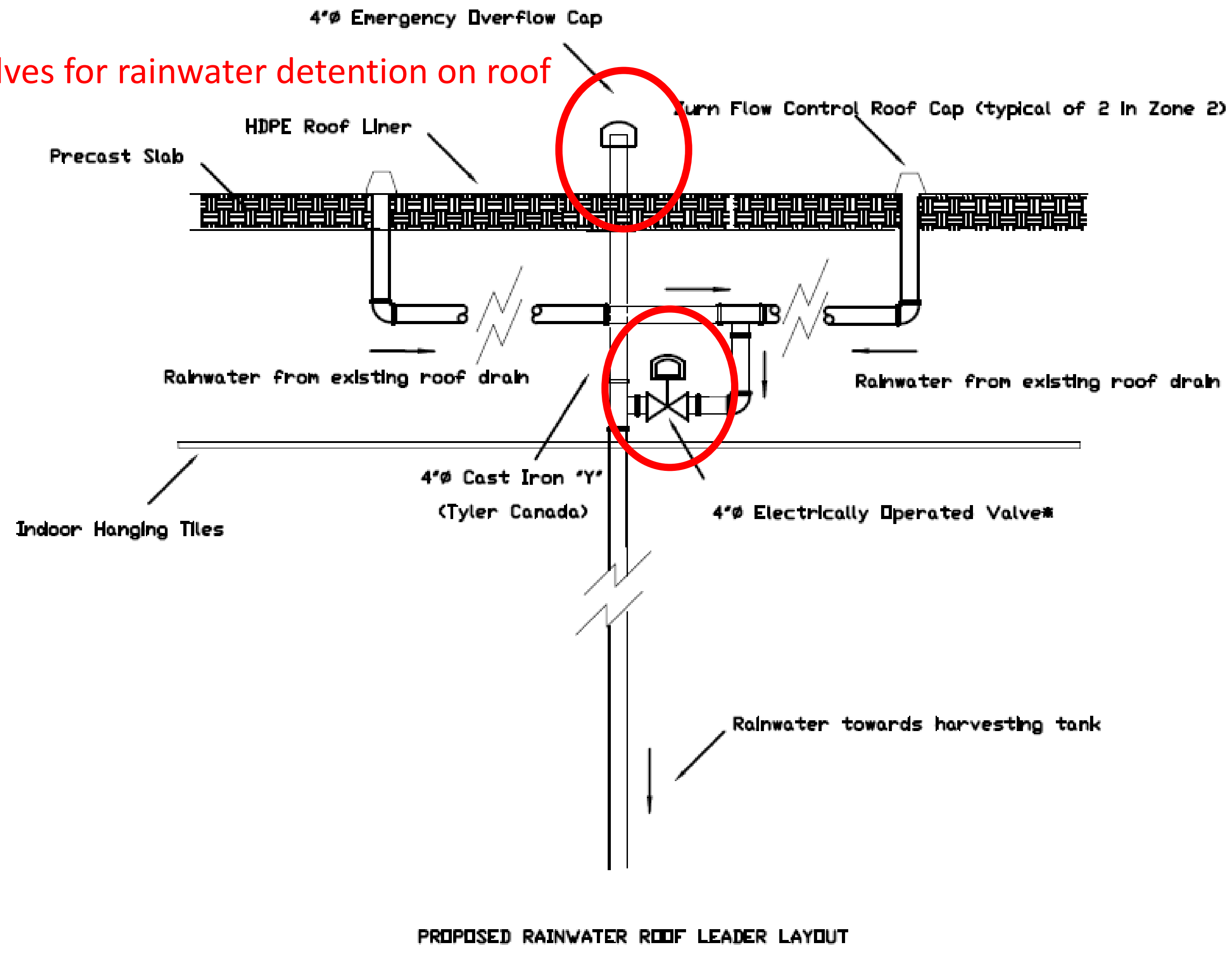
Proposed Roof Leader Retrofits



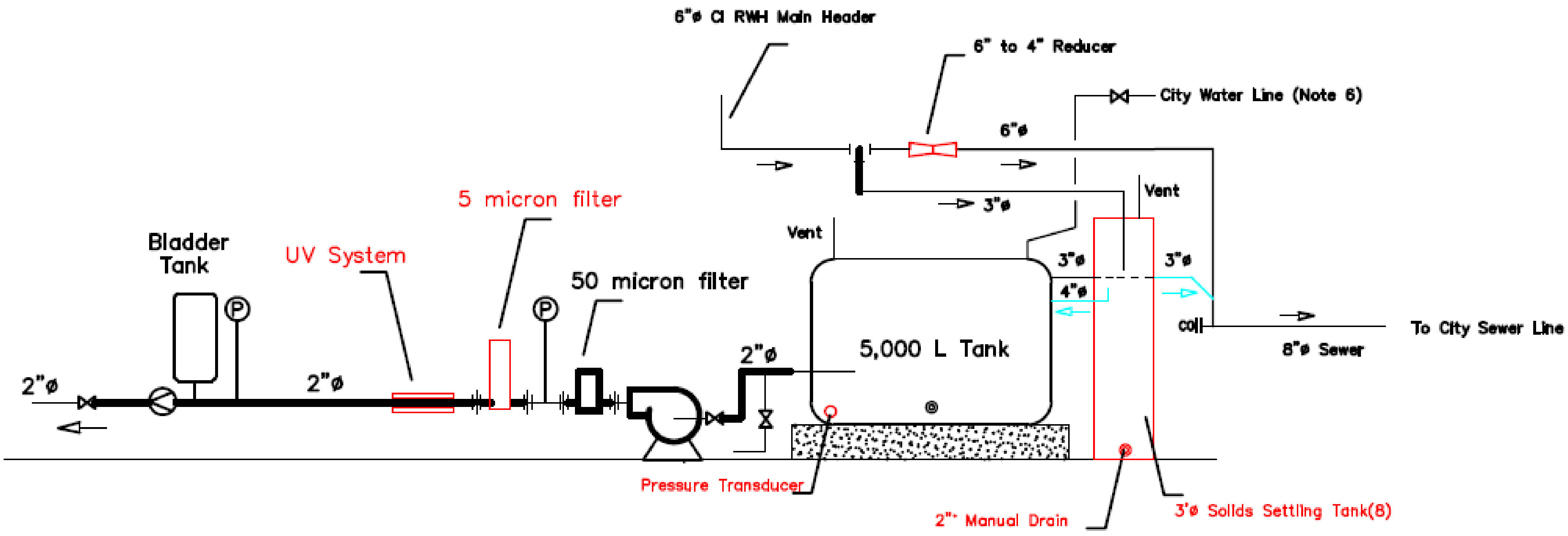
EXISTING RAINWATER ROOF LEADER LAYOUT

Proposed Roof Leader Retrofits

Add modulating valves for rainwater detention on roof



Rainwater Harvesting Tank with Proposed Improvements



RWH System Proposed Retrofitting

Solids Removal Tank – Disinfection System – Flow Restriction

Conceptual Diagram

Benefits of Smart Blue Roof Systems

- Optimized system
  - Stormwater management
  - Water Efficiency
  - Energy Efficiency

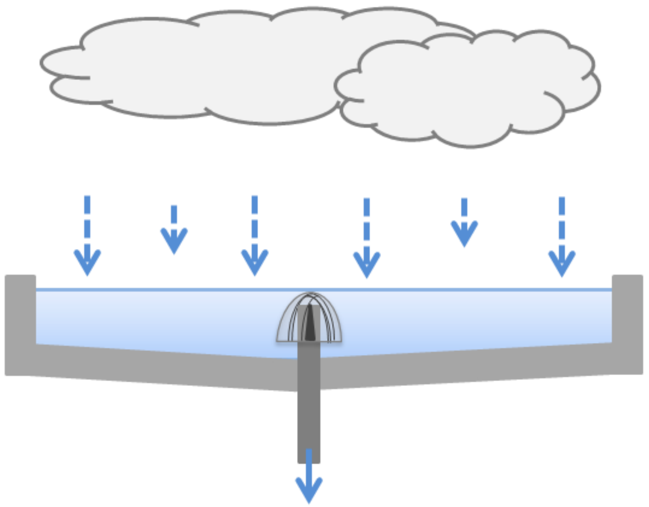
- Benefits property owners, municipalities and the community

Technical Feasibility
Stormwater Management

- Roof structural capacity equivalent to 130 mm ponding depth
- According to building code the max storage allowed is 150mm
- Blue roof storage volume 40 m^3 + rainwater harvesting tank 5 m^3
  - Total storage for the entire system is **45 m^3**

- Smart blue roofs provide:
  - Peak flow control
  - Runoff mitigation

  (100-year Mississauga design storm event captured by system)



Technical Feasibility
Water Reuse/Rainwater Harvesting

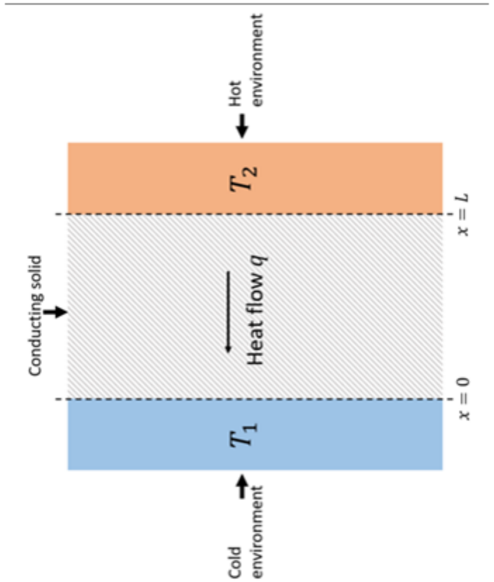
- Current average non-potable water demand **1.58 m^3/day**

- Current average potable and non-potable water demand **5.68 m^3/day**

- Smart blue roof with rainwater harvesting system can meet water demands of **8.84 m^3/day** *(if rainwater was stored on roof for a maximum of three days)*

- Opportunity to expand non-potable uses at CVC office (ie. irrigation)

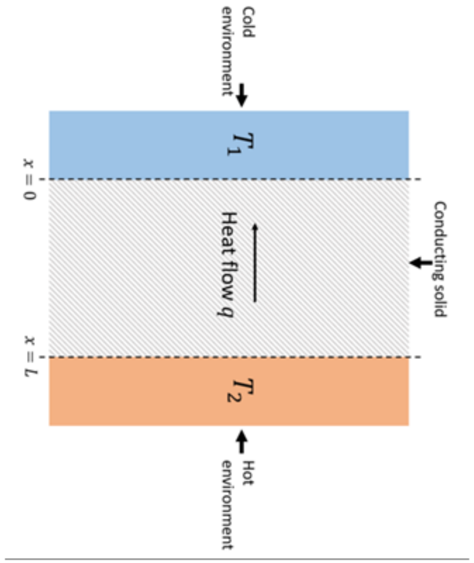
Technical Feasibility
Evaporative Cooling



CVC Office Without Smart Blue Roof

Heat flows into ceiling through roof from liner

21.3 GJ of heat is added onto the HVAC system load



CVC Office With Smart Blue Roof

Heat flows from ceiling through roof into water

13.3 GJ of heat is removed from the load on the HVAC system

0.56 kg/y/m^2 GHG Reduction

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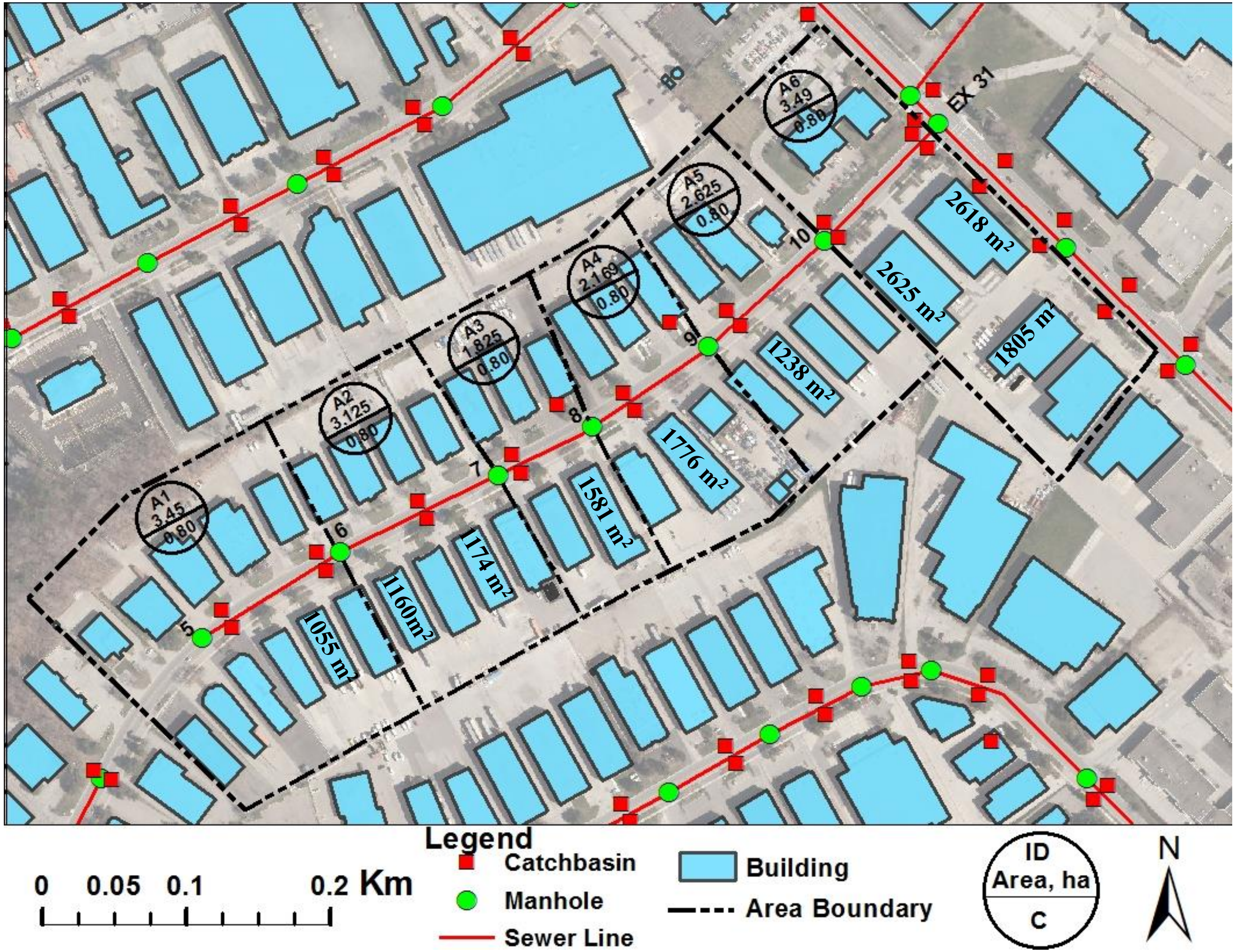
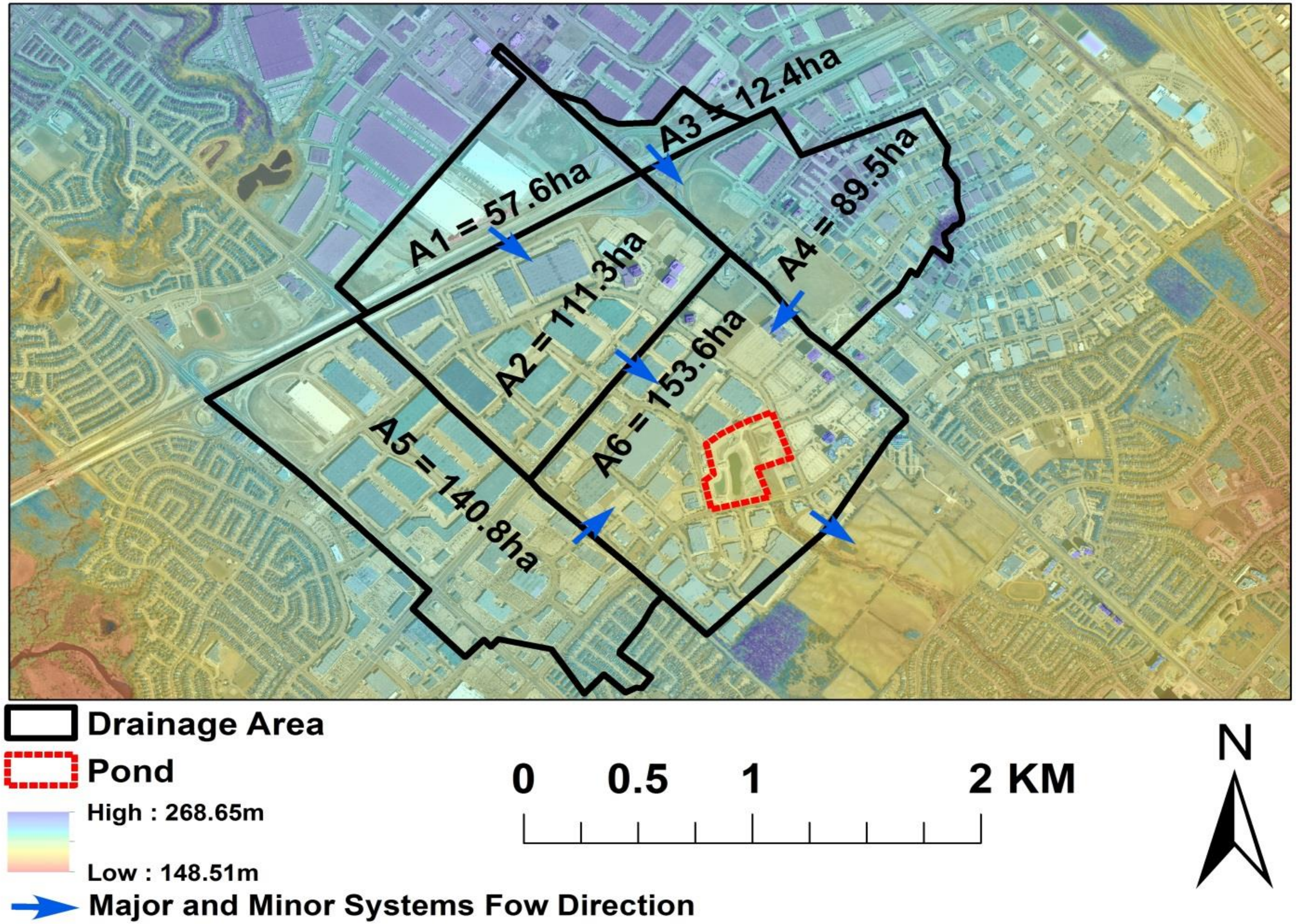
Feasibility Study - Case Studies

Typical Industrial Commercial Neighbourhood with no Existing Stormwater Controls

Selected Industrial Area, Mississauga

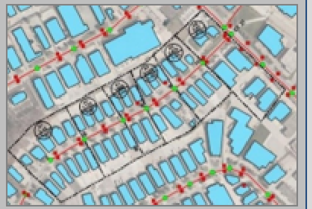


Drainage Area Served by SWM Pond



Financial Feasibility

Economies of Scale

	CVC Head Office	Street Scale	Neighbourhood Scale
			
BENEFITS			
Reduction in Pond Storage Volume Requirement (m^3)			
Stormwater Benefits & Savings to Landowner * ($/yr)			
Annual Water Savings (m^3/yr) & Water Purchasing Cost Savings ($/yr)			
Annual Energy Savings ($/yr)			
Stormwater Benefits & Savings to Municipality			
Property Tax Revenue ($/yr)			
Avoided Land Acquisition Costs			
Avoided Flooding Damages			
Avoided Storm Sewer Pipe Replacement			
Avoided Matheson Pond Construction Cost			
COSTS			
Non-scalable retrofits			
Scalable retrofits			
Liner			
Smart system components (controller, software, development and commissioning)			
Annual Operation & Maintenance ($/yr)			

Cost-Benefit Increases →

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Intact Adaptation Action Grant for Smart Blue Roof Implementation

intact

Focus Area: Testing Concepts

ENVIRO STEWARDS

Interpump

Key Performance Indicators

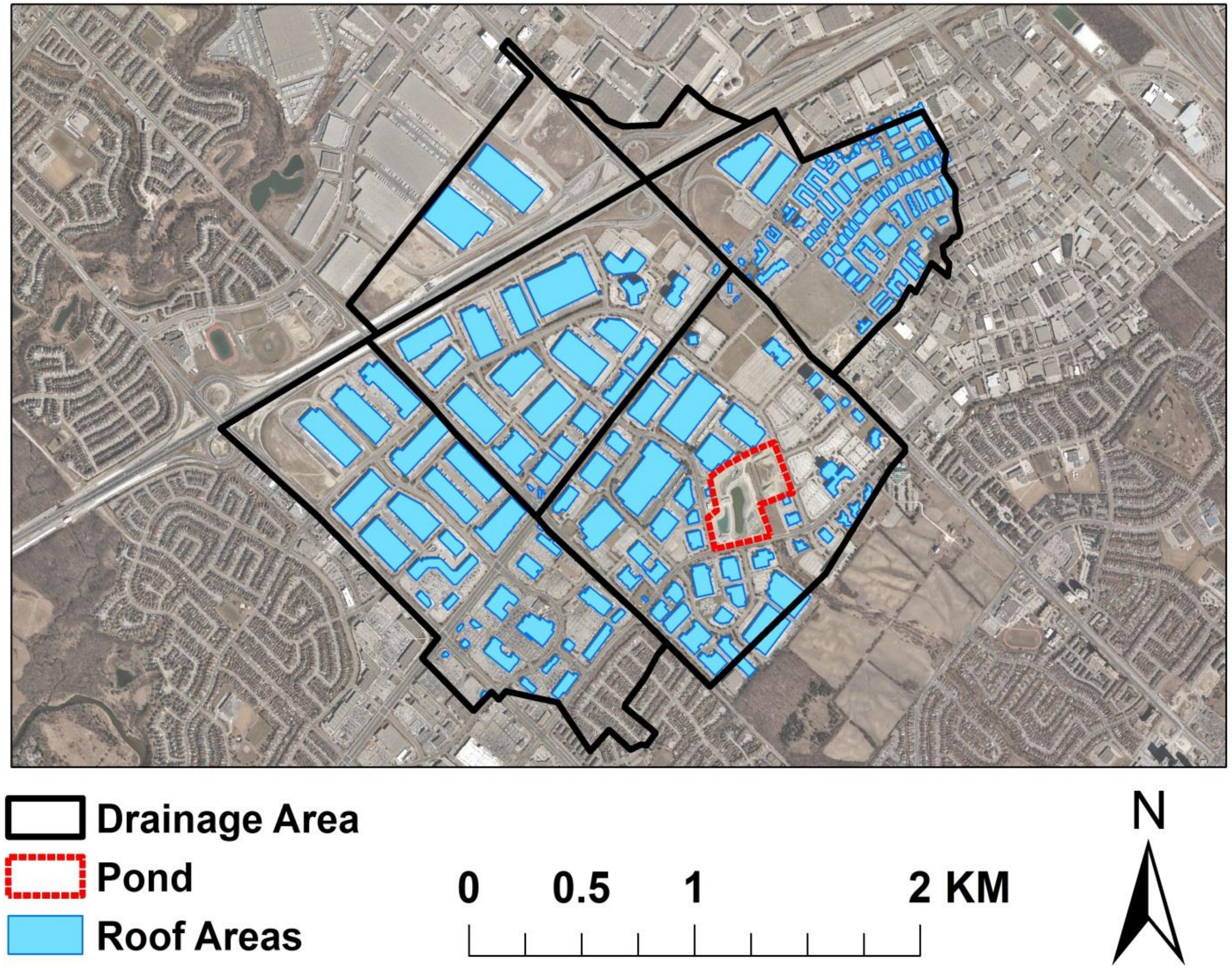
Total volume (m^3) of stormwater removed from the storm sewer system

Total peak flow reduction (m^3/s) to storm sewer system

Estimate electricity reductions

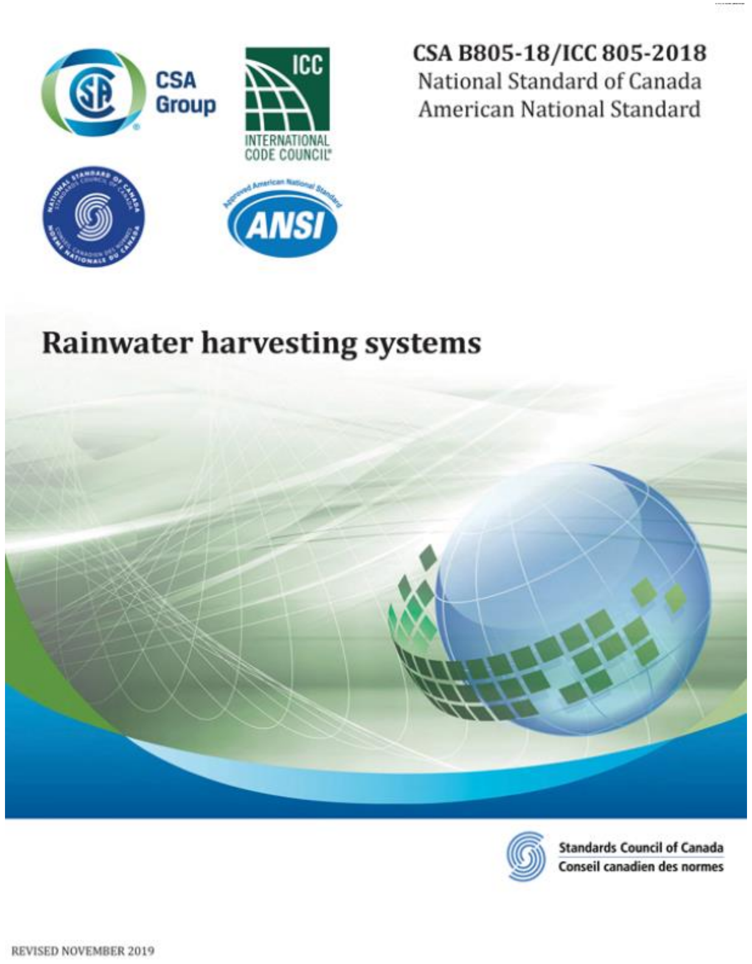
Estimate GHG emission reductions

Benefits of Scaling Up



Design and Permitting Requirements

New RWH Standard



- New standard, not yet part of Ontario Building Code
- To be implemented in 2021/22
- Pilot project should remain current and leading edge for years to come
- Water Safety Plan requires doing upfront risk assessment and ongoing monitoring program

Water Safety Plan

5.1.2.3 Elements of a WSP

a) Based on intended uses, the elements of a WSP shall include the following:
b) site assessment for source water suitability;
c) fit for intended uses;
d) hazard identification and risk prioritization;
e) system design and identification of control points;
f) operational monitoring, system verification, and response; and
g) supporting programs, measurement procedures, and documentation.

Criteria from CSA B805

Table 8.3
Roof runoff water treatment requirements for multi-residential and non-residential applications
(See Clauses 8.1.1, 8.1.3, and 8.2.1.)

Application				Minimum performance criteria				Minimum prescriptive requirements				
				Log reduction(% reduction)				Options for post-storage treatment before end use				
								UV‡‡		Chemical-based disinfectants§§		Microfiltration or ultrafiltration
End use tier	Category	Potential for human contact	Examples of uses	Viruses	Bacteria**	Protozoa	pH	Filtration	Disinfection	Filtration	Disinfection	
1	Non-potable	Low	• Trap primers • Spray irrigation (restricted access or exposure)*** • Surface and subsurface irrigation (drip, bubbler) • Fire protection • Ice rinks	0	0	0	—	None§				
2	Non-potable	Medium	• Toilet and urinal flushing • Clothes washing • Rooftop thermal cooling	0*	2(99%)	2(99%)	—	5 µm	16 mJ/cm²	1 µm absolute**	CT for 2 Log reduction for bacteria and at least 0.5 mg/L chlorine residual**	0.5 µm‡ with at least 0.5 mg/L chlorine residual
			• HVAC evaporative cooling (e.g., cooling	Treatment shall consider equipment manufacturer water quality requirements and be designed in accordance to ANSI/ASHRAE 188								

Building Permit – Section 7

Nov 2021

7.4.10.4. Hydraulic Loads from Roofs or Paved surfaces

(1) Except as provided in Sentence (2), the hydraulic load in litres from a roof or paved surface is the maximum 15 min rainfall
determined in conformance with MMAH Supplementary Standard SB-1, "Climatic and Seismic Data", multiplied by the sum of,
(a) the area in square metres of the horizontal projection of the surface drained, and
(b) one-half the area in square metres of the largest adjoining vertical surface.

(2) *Flow control roof drains* may be installed provided,
(a) the maximum drain down time does not exceed 24 h,
(b) the roof structure is designed to carry the load of the stored water,
(c) one or more scuppers are installed not more than 30 m apart along the perimeter of the *building* so that,
(i) the scuppers are designed to handle at least 200% of the 15-minute rainfall intensity, and
(ii) the maximum depth of controlled water is limited to 150 mm,
(d) they are located not more than 15 m from the edge of the roof and not more than 30 m from adjacent drains, and
(e) there is at least one drain for each 900 m^2.

(3) Where the height of the parapet is more than 150 mm or exceeds the height of the adjacent wall flashing,
(a) emergency roof overflows or scuppers described in Clause (2) (c) shall be provided, and
(b) there shall be a minimum of two roof drains.

Intent and Objective statements relating to 24hr drawdown

- limit the probability…a person…will be exposed to an unacceptable risk of illness due to unsanitary conditions caused by contact with **contaminated surfaces**.
- limit the probability…a person…will be exposed to an unacceptable risk of illness due to unsanitary conditions caused by **contact with vermin and insects**.
- To minimize the risk of **generation of contaminants**.
- To limit the probability that inadequate drainage will lead to **stagnant water remaining on roof tops, which could lead to the growth of mould or mildew**, which could lead to harm to persons.

Alterative Solution A

- Treat water stored on roof beyond 24 hr to a safe level, use CSA B805 as a reference although it generally only applies to treatment before final end use

Alterative Solution A: Criteria from CSA B805

Table 8.3
Roof runoff water treatment requirements for multi-residential and non-residential applications
(See Clauses 8.1.1, 8.1.3, and 8.2.1.)

Application				Minimum performance criteria				Minimum prescriptive requirements				
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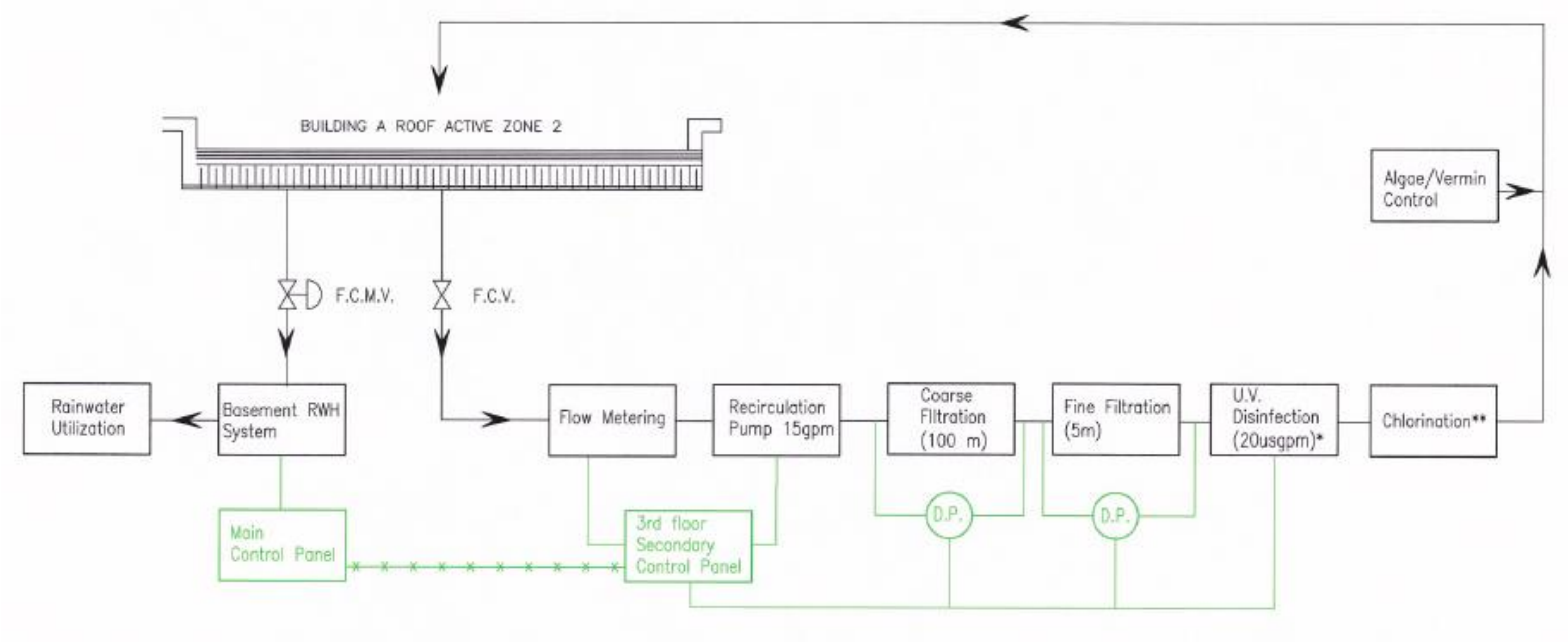
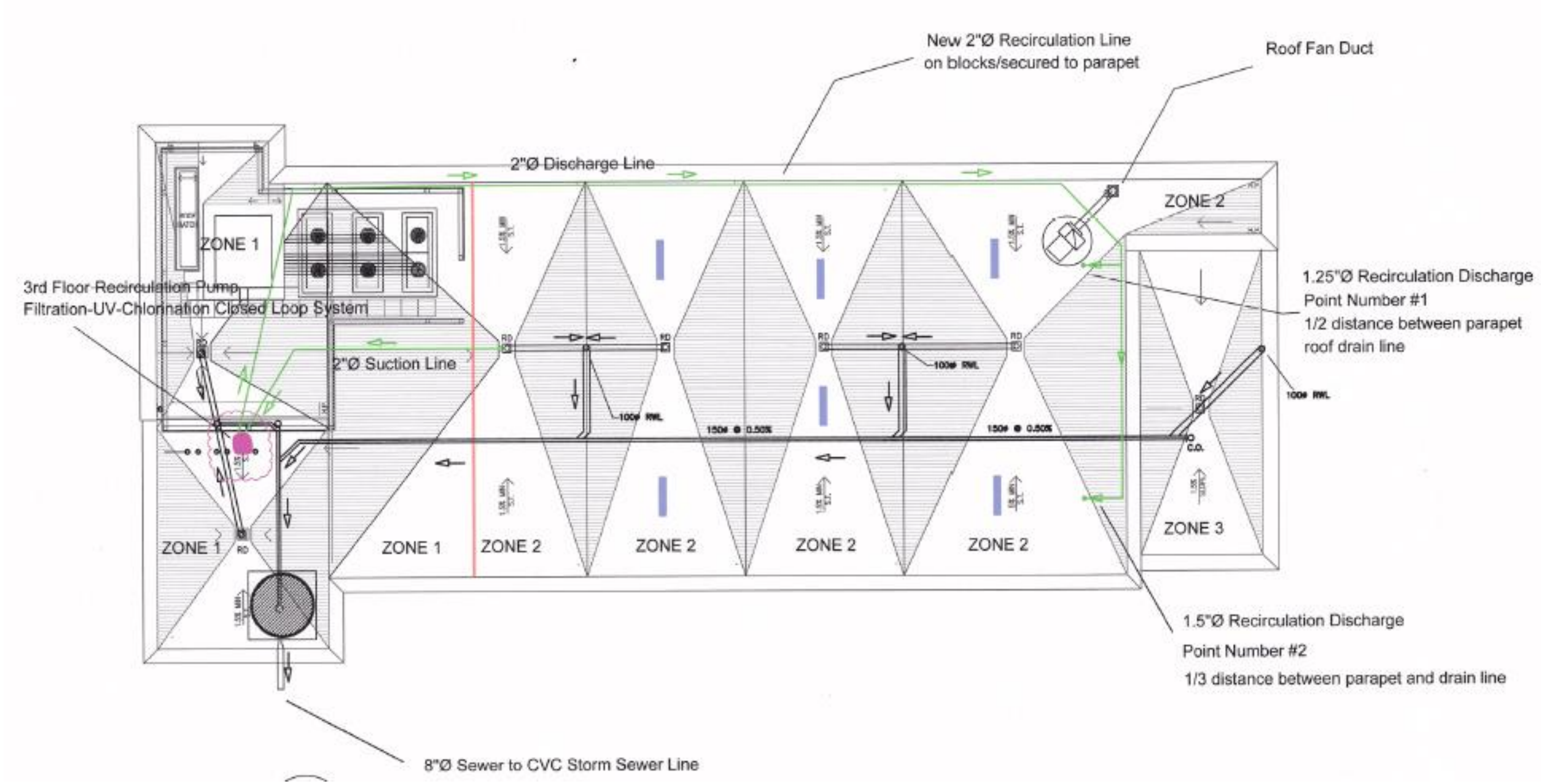
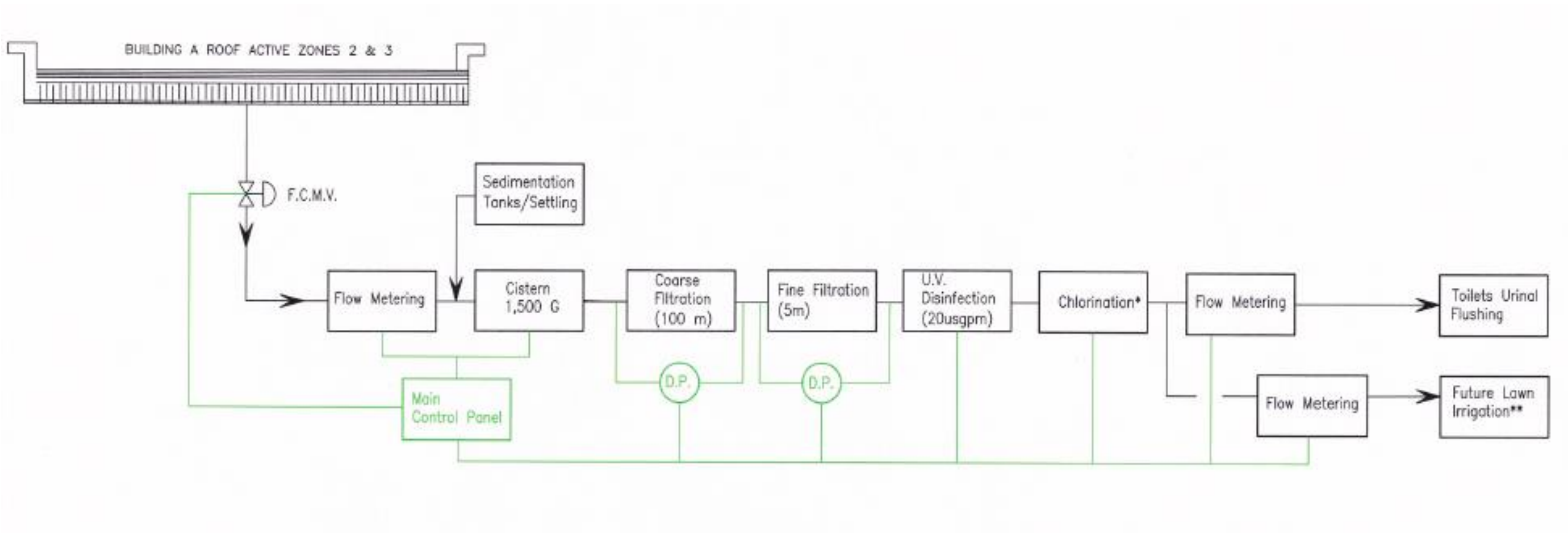
Rooftop Treatment System



Rooftop Treatment System

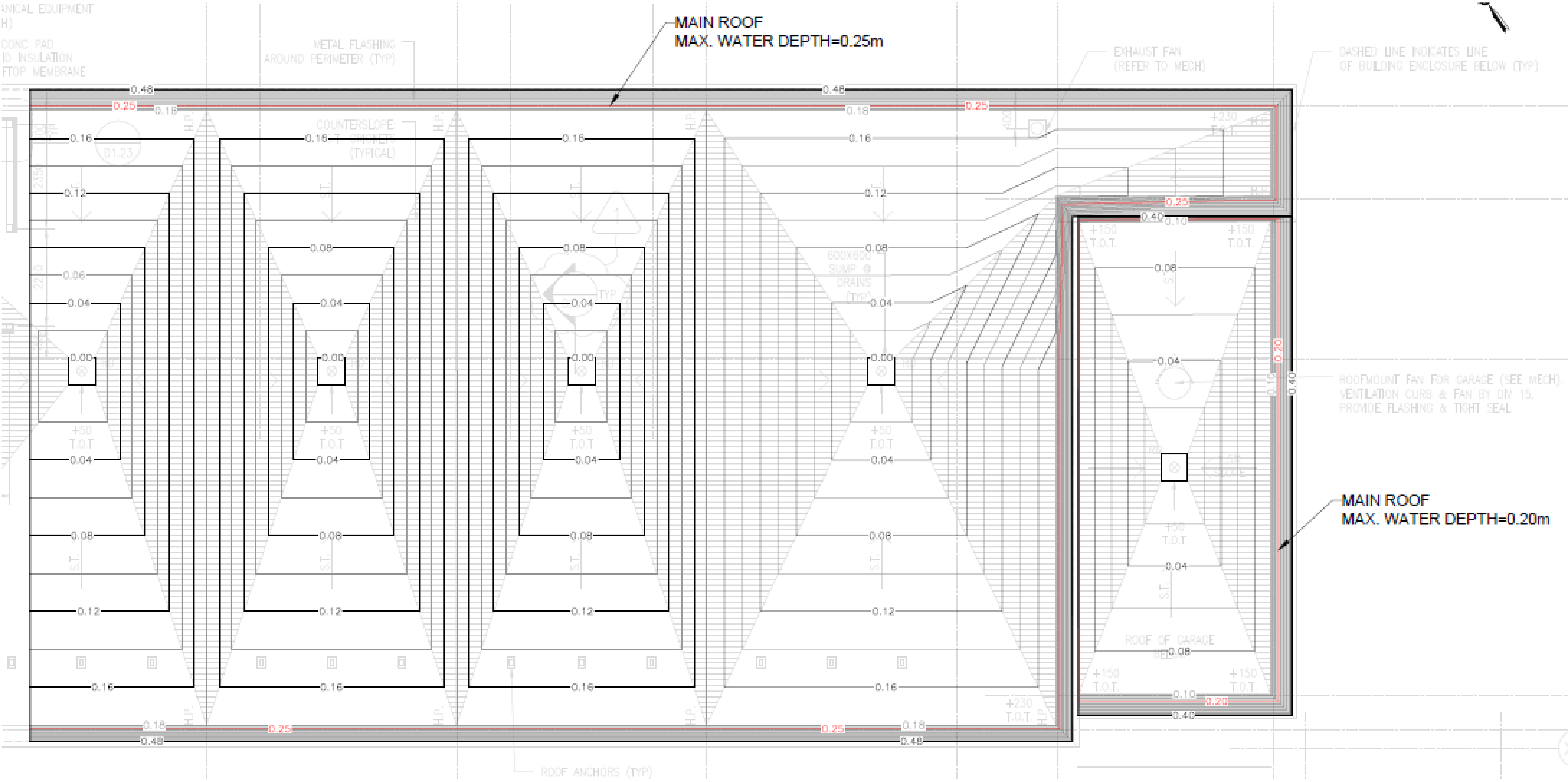


Basement Treatment System



Intent and Objective statements relating to 150mm max depth

- To limit the probability that an inadequate **load carrying capacity for a roof** or excessive depth of water on the roof will lead to an inability of roofs to support gravity loads imposed by standing water, which could lead to structural collapse, which could lead to harm to persons.

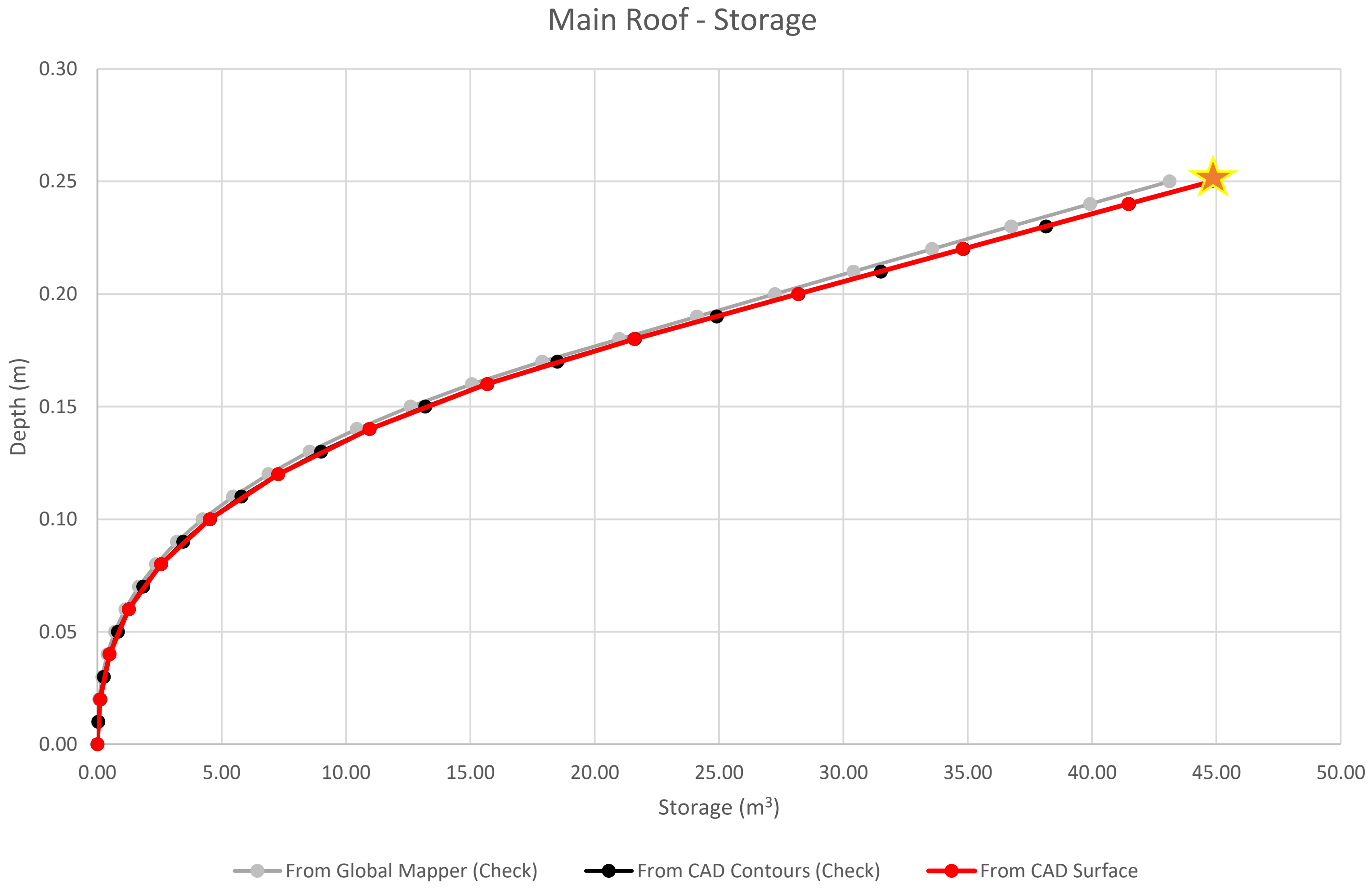

MAIN ROOF
MAX. WATER DEPTH=0.25m
METAL FLASHING AROUND PERIMETER (TYP)
COUNTERSLOPE CRICKETS (TYPICAL)
EXHAUST FAN (REFER TO MECH)
DASHED LINE INDICATES LINE OF BUILDING ENCLOSURE BELOW (TYP)
600X600 SUMP @ DRAINS (TYP)
ROOFMOUNT FAN FOR GARAGE (SEE MECH). VENTILATION CURB & FAN BY DIV 15. PROVIDE FLASHING & TIGHT SEAL
MAIN ROOF
MAX. WATER DEPTH=0.20m
ROOF ANCHORS (TYP)

Alterative Solution B

- Show that storing water between 75mm and 250mm on our sloped roof is equivalent to storing 130mm across a perfectly flat roof, so we are still within the snow load
- Structural assessment of roof loading capacity and stage-storage curve to determine depth-volume relationship and max storage capacity

Snow load

130mm x 344m^2 = 45m^3



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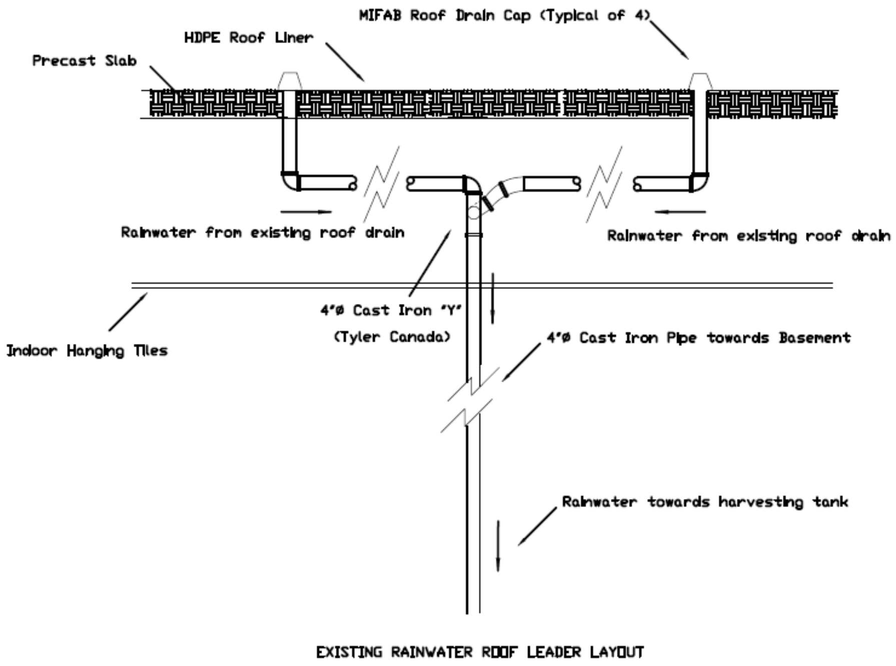
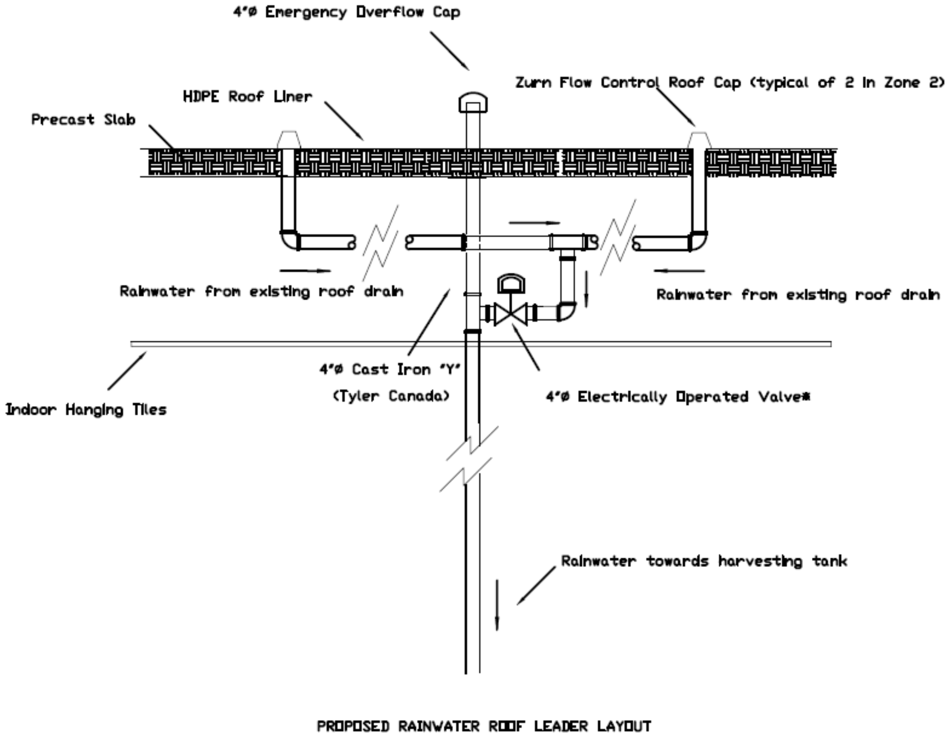
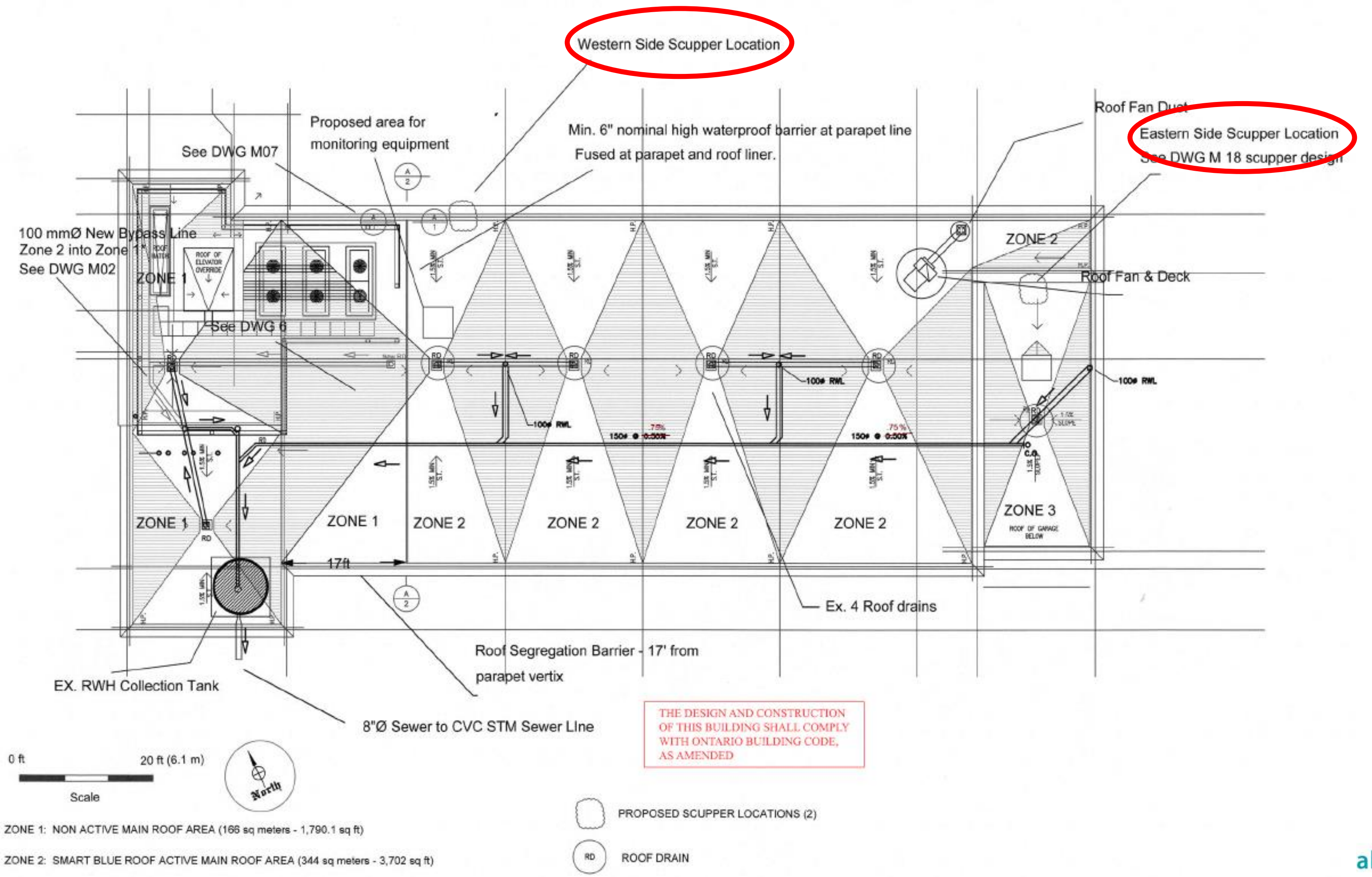
Roof Leader Retrofits, Overflows and Scuppers

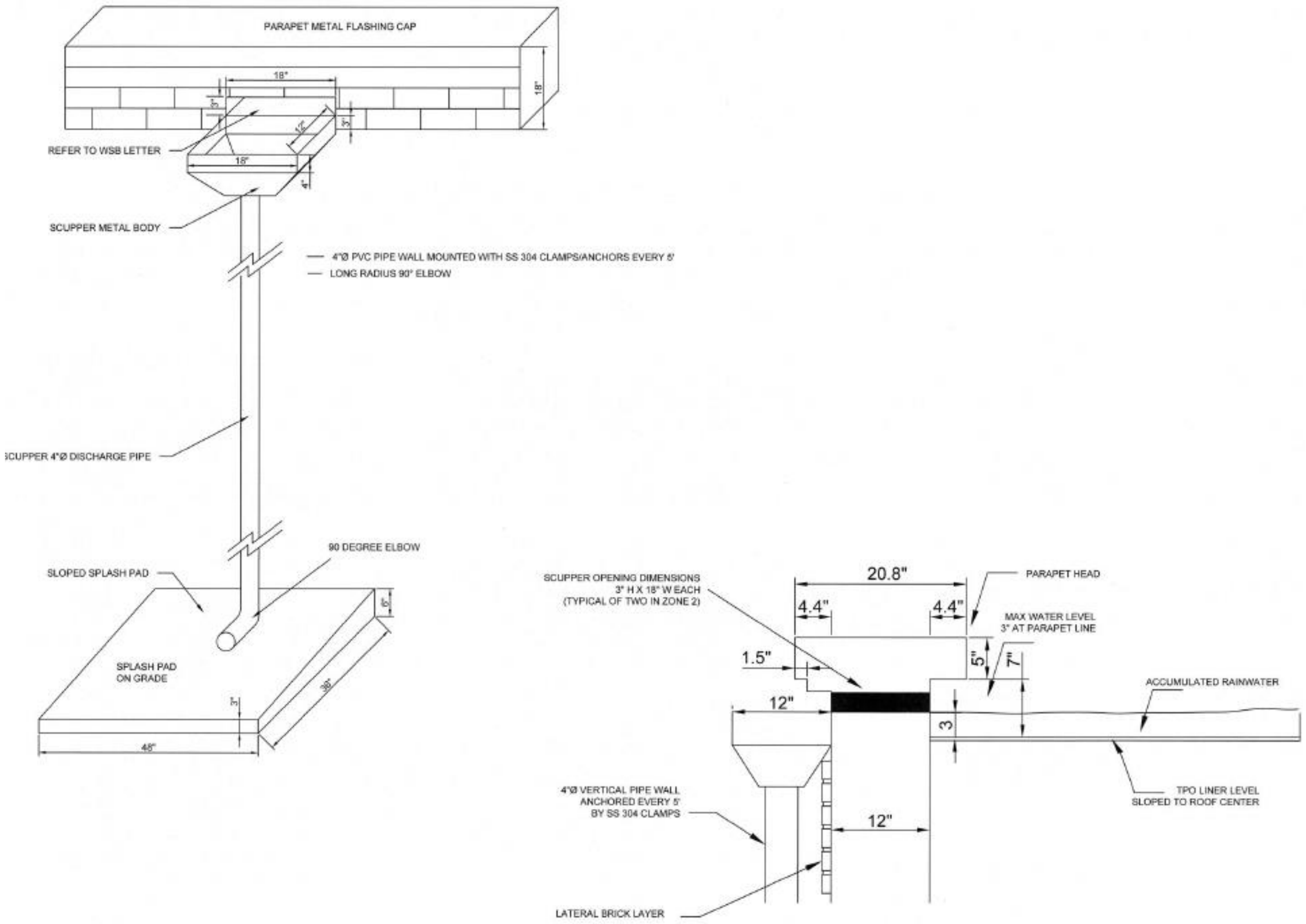




Scupper Locations



Scupper Design



Other interesting design features

- Bird repeller system
- Leak detection testing/sensors
- Adjustable overflow height
- Potential for irrigation

Build Permit Issued!

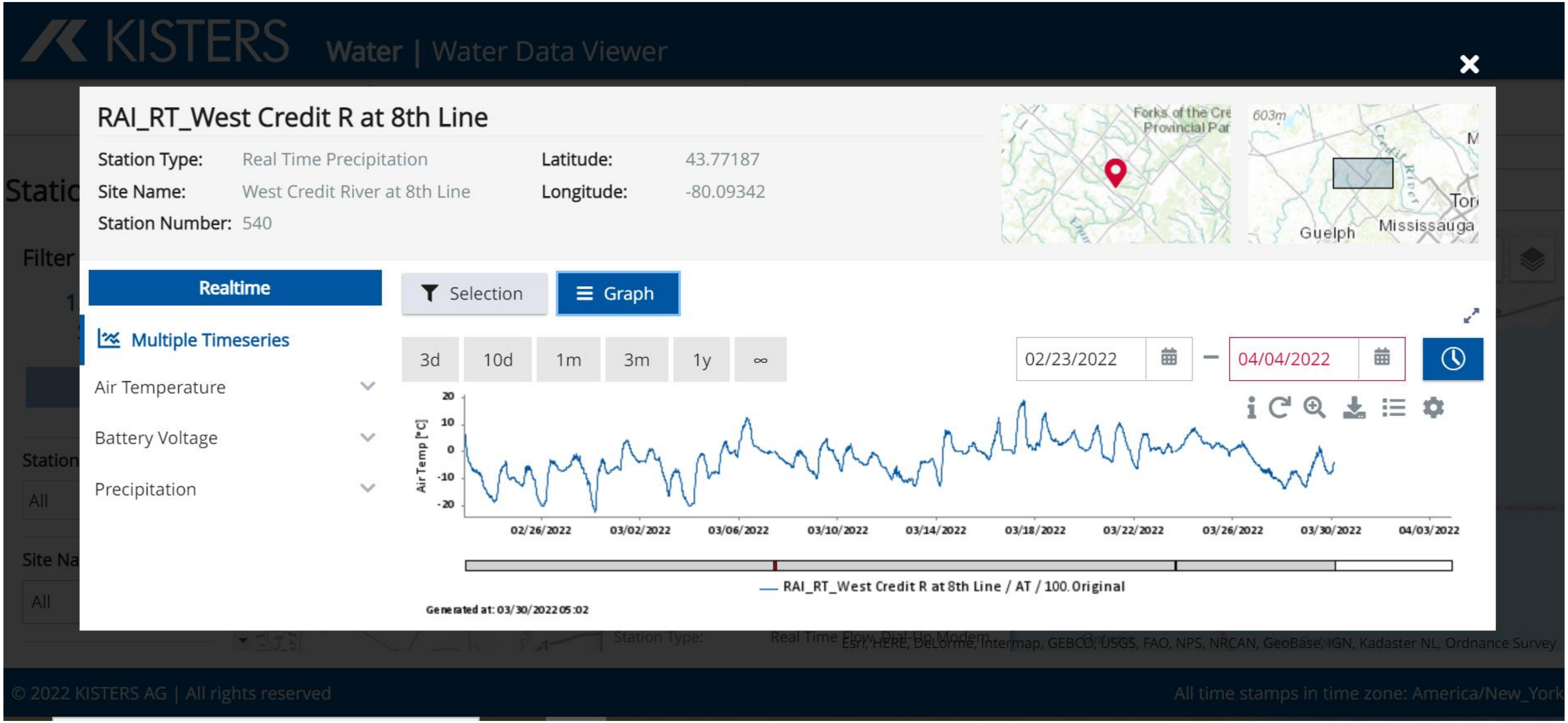
BUILDING PERMIT NOTICE

MISSISSAUGA

City of Mississauga
Planning and Building Department
300 City Centre Drive
MISSISSAUGA, ON L5B 3C1

Permit# **BP 3ALT 21 9123**	Web Access ID **2VY6P7AE**	Issuance Date **2022-01-05**
Municipal Address **1255 OLD DERRY RD**	Bldg	Unit

Smart Blue Roof Monitoring and Control Logic


KISTERS
Water | Water Data Viewer
RAI_RT_West Credit R at 8th Line
Station Type: Real Time Precipitation
Site Name: West Credit River at 8th Line
Station Number: 540
Latitude: 43.77187
Longitude: -80.09342
Guelph
Mississauga
Realtime
Selection
Graph
Multiple Timeseries
Air Temperature
Battery Voltage
Precipitation
3d
10d
1m
3m
1y
02/23/2022
04/04/2022
Air Temp [°C]
02/26/2022
03/02/2022
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03/10/2022
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RAI_RT_West Credit R at 8th Line / AT / 100.Original
Generated at: 03/30/2022 05:02
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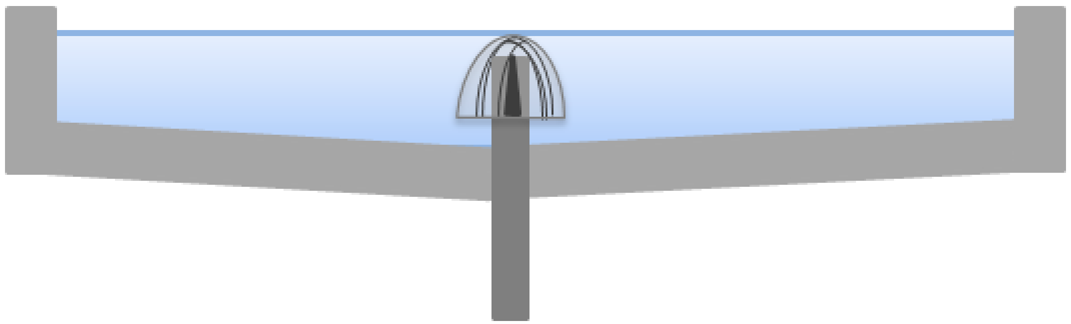
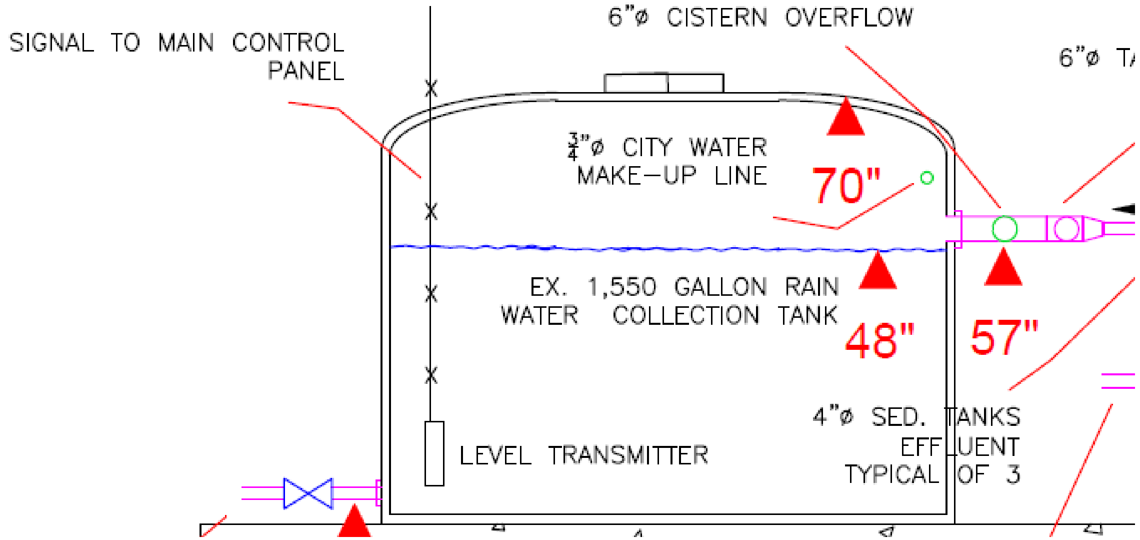
Basic Measurements and Control Logic

- Measure water level on roof with ultrasonic level sensor
  - Recirculate and treat rooftop water at minimum level



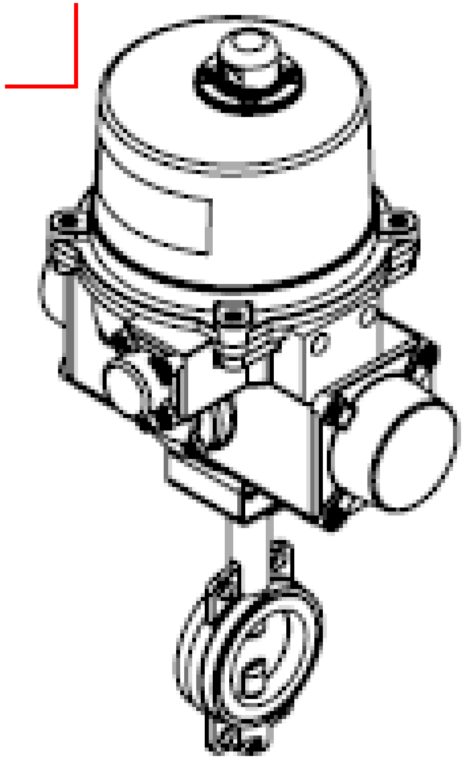
Basic Measurements and Control Logic

- Measure water level in basement cistern
  - Open rooftop flow control drain to fill cistern when at low level, close at high level



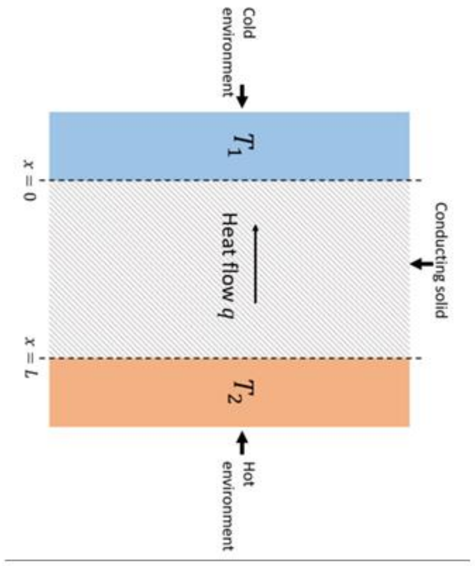
Basic Control Logic

- When there is demand from the cistern
  - Roof drain valves are modulating so can be opened to different amounts to control flow



Basic Measurements and Control Logic

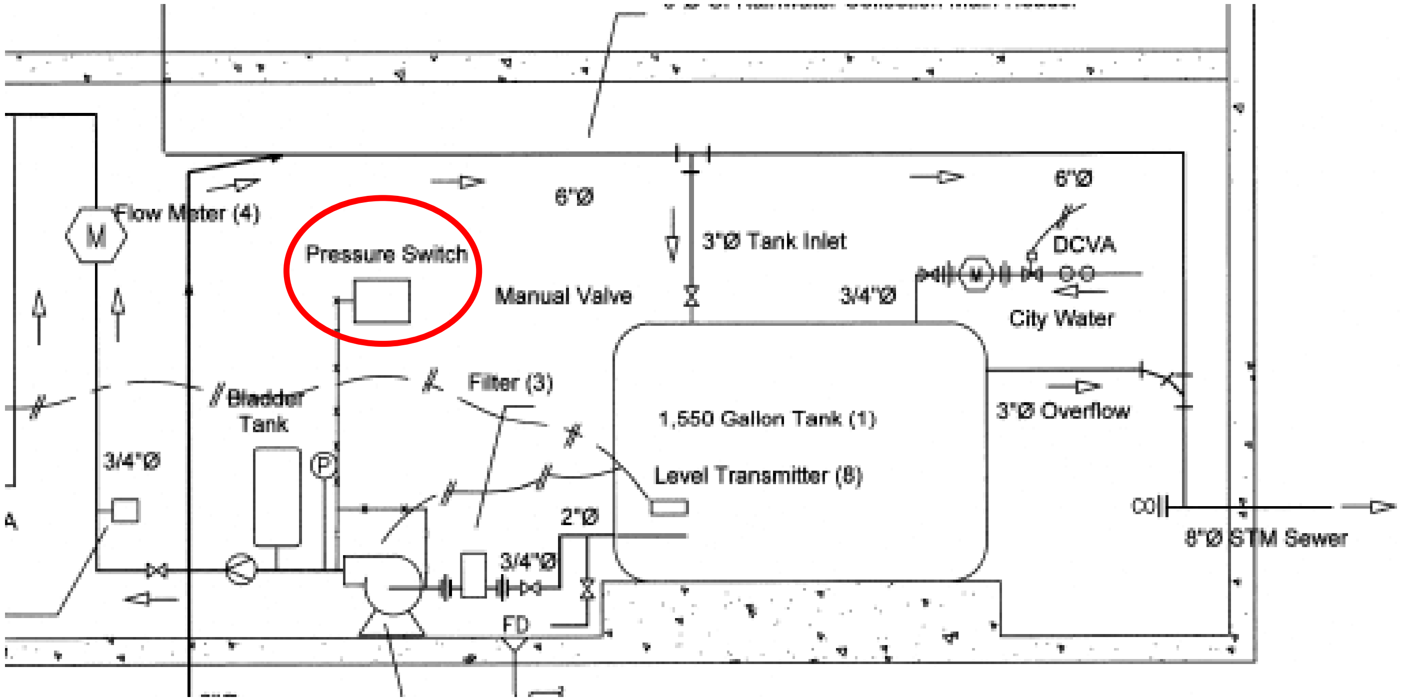
- Measure temperature of roof slab, outer and inner surfaces, with temperature sensors
  - Calculate heat load reduction on building



CVC Office With Smart Blue Roof

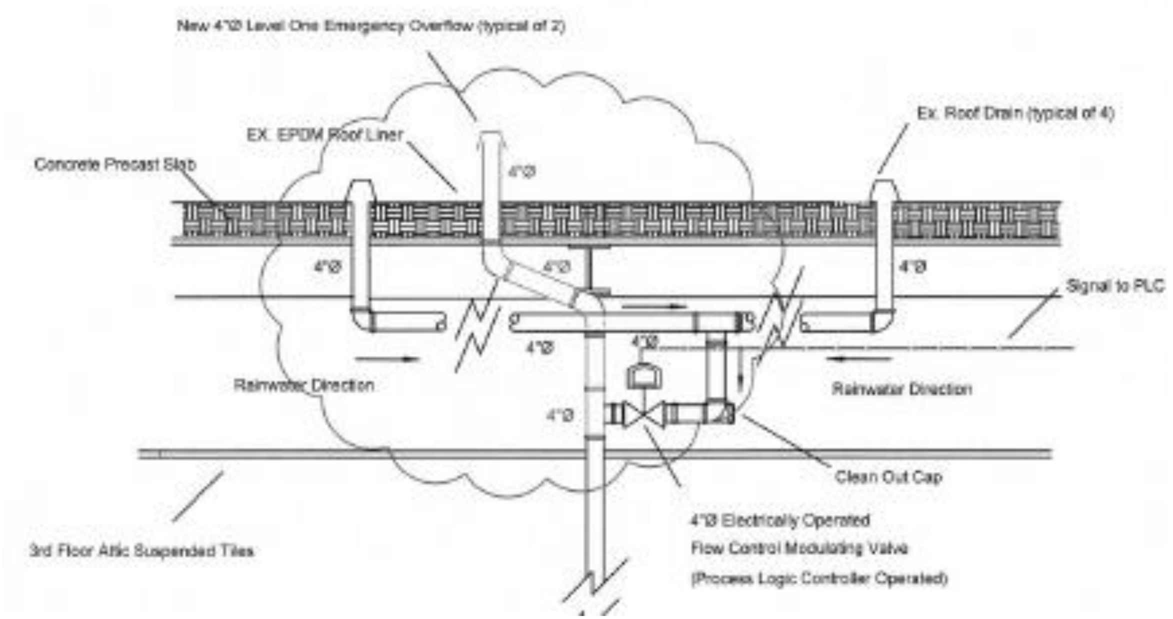
Basic Measurements and Control Logic

- Measure pressure in demand line
  - When pressure drops, turn on distribution pump



Basic Control Logic

- Overflow Alarm
  - If water reaches overflow level send alarm



Scenario A: Maximize Water Reuse

- Whenever tank level reaches low level and there is water on the roof, refill basement cistern

Scenario B: Maximize Evaporative Cooling

- When outdoor temperature > 20C, do not open roof drain if volume is less than xx amount (say 15mm, 3 days of evaporation in a hot period of the summer)

O&M

- Consumables (filters, UV bulbs)
- Visual checks
- Maintenance and Cleaning
- WSP key considerations


HAYWARD
Automatic Chemical Feeder
CL200EF


DANGER


SUPPLY
HEATING

Construction Delay – Roof Leak

- As rooftop construction commenced, **existing moisture** was encountered within the roof membrane
- This discovery delays construction to the **Spring of 2023**, so the membrane and insulation can be replaced

Project Next Steps

- Receive equipment
- Resume construction!
- Monitoring – will be developing a longer-term monitoring plan, open to collaboration
- O&M
- Disseminate knowledge (tours, case study, report)

Control System Configuration + Visualization

- Phase 2: Predictive weather and optimization using Kister's RTO

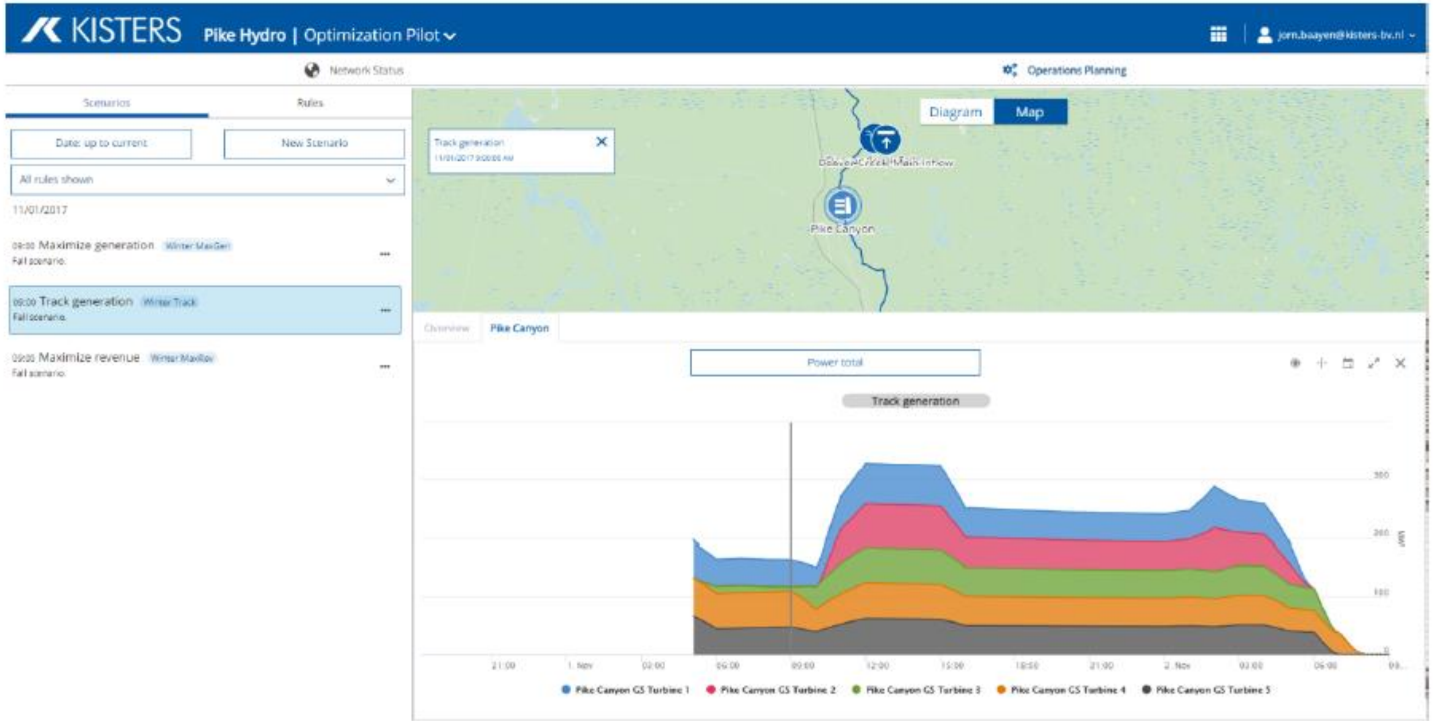


Figure 8 : Inspecting unit-level generation at a power station.

Smart Blue Roof Implementation Workplan

Developed a Detailed Design	Tendering/ Permitting	Construction	Operation & Performance Monitoring	Disseminating Lessons
October 2021	June 2021 – Jan 2022	Summer 2022 – Spring 2023	Spring 2023 – Fall 2023	Winter 2023 – Summer 2024

Questions

Thank You

For more information:

Contact

Name: Rohan Hakimi, P.Eng., M.A.Sc.
Phone: 437-248-1564
Email: rohan.hakimi@cvc.ca

Name: James Cowan, E.I.T.
Phone: 437-221-8519
Email: james.cowan@cvc.ca

Name: Samantha Pelayo Cazares, E.I.T., M.A.Sc.
Phone: 437-922-4634
Email: samantha.pelayo@cvc.ca