# Stormwater Management Report – Bachman Terrace Residential Development

Project # 160401069

Prepared for:
Tega Developments

Prepared by:
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# Sign-off Sheet

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Prepared by ________________________________________
(signature)

Dustin Thiffault, P.Eng.

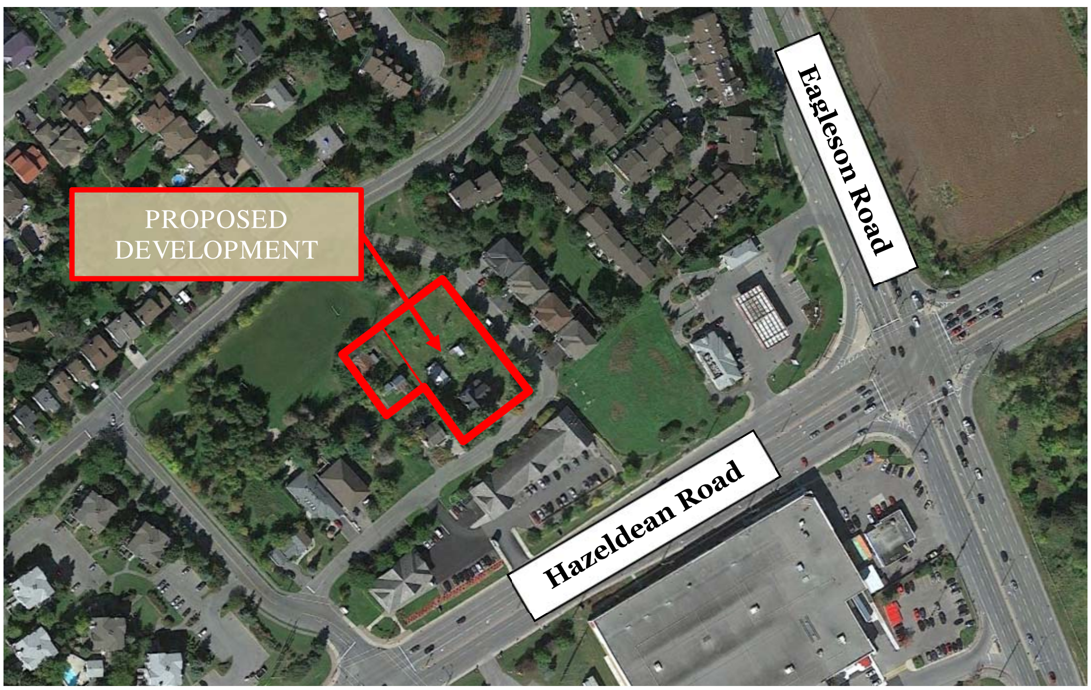
# Table of Contents

# 1.0 Introduction and Background

## 1.1 OVERVIEW

Stantec Consulting Ltd. has been commissioned by Tega Developments to prepare the following stormwater management report in support of the proposed 25 unit residential development at 19 & 23 Bachman Terrace. The subject property is located within the City of Ottawa (formerly Kanata) and is currently zoned Residential (R1M). The development is bordered by Bachman Terrace to the north and east, existing residential to the south, and Irwin Gate Park to the west. The property comprises approximately 0.34ha of land and is indicated in Figure 1.

Figure 1: Approximate Location of Proposed Residential Development



# 2.0 Criteria and Constraints

## 2.1 OBJECTIVES

The City of Ottawa has required that the post-development peak rate of site runoff not exceed the predevelopment release rate for the site. Stormwater may be detained, if necessary, to ensure that the allowable release rate is not exceeded.

Stormwater management facilities currently do not exist on-site. This design aims to provide on-site storage to ensure that the allowable site release rate has not been exceeded in accordance with the criteria and constraints listed below to suit the revised site layout.

## 2.2 SWM CRITERIA AND CONSTRAINTS

The stormwater management criteria for the proposed site are based on City of Ottawa Sewer Design Guidelines (2004) and on a pre-consultation meeting with City of Ottawa Staff. The following summarizes the criteria used in the preparation of this stormwater management plan:

- Maximum discharge during the 5 and 100 year storms to be restricted to that of predevelopment conditions.
- Maximum 100 yr ponding depth of 0.30 m in parking and access areas.
- Provide adequate emergency overflow conveyance off-site.
- Size storm sewers to convey 5 yr storm event, assuming only roof controls are imposed (i.e. provide capacity for system without inlet-control devices installed).
- Size storm culverts to convey 50 yr storm event (local urban road, over 6m culvert span).
- Size storm sewers using an inlet time of concentration (Tc) of 10 minutes.
- On-site quality control not required for development (pre-consultation meeting).

## 2.3 GEOTECHNICAL CONSIDERATIONS

A geotechnical investigation titled *Geotechnical Investigation – Proposed Redevelopment – 19 and 23 Bachman Terrace* has been prepared for the subject site (Houle Chevrier, June 2014). The report indicates the presence of bedrock within approximately 1.0m from the surface of the existing site. In consideration of this and the lack of storm sewers within the Bachman Terrace ROW, subsurface storage has not been considered for use within the subject site.

# 3.0 Stormwater Management Design

## 3.1 DESIGN METHODOLOGY

The intent of the stormwater management plan presented herein is to mitigate any negative impact that the proposed development will have on the existing storm sewer infrastructure, while providing adequate levels of service to the proposed buildings and access areas. The proposed stormwater management plan is designed to detain runoff on the rooftop and the surface to ensure that peak flows after construction will not exceed the predevelopment flow rates from the site.

## 3.2 WATER QUANTITY CONTROL

The Modified Rational Method was employed to assess the quantity and volume of runoff generated during post-development conditions. The site was subdivided into subcatchments (subareas) tributary to stormwater controls as defined by the location of inlet control devices, and used in culvert design (see Appendix B). A summary of subareas and runoff coefficients is provided in Appendix A, and Drawing SD-1 indicates the stormwater management subcatchments.

### 3.2.1 Allowable Release Rate

The predevelopment release rate for the area has been determined using the rational method. Existing buildings and access areas were considered as hard surfaces (C=0.9), while the remainder of the site is grassed (C=0.2). A time of concentration for the predevelopment area (15 minutes) was assigned during a pre-consultation meeting with City of Ottawa staff. C coefficient values have been increase by 25% for the 100-year storm event per City of Ottawa guidelines. Peak flow rates have been calculated using the rational method as follows:

$Q = 2.78\ CiA$

Where: Q = peak flow rate, L/s
A = drainage area, ha
I = rainfall intensity, mm/hr (per Ottawa IDF curves)
C = site runoff coefficient

Target release rates for the site are summarized in the table below:

### Table 1: Target Release Rates

| Design Storm | Target Flow Rate (L/s) |
|---|---|
| 5-Year | 22.7 |
| 100-Year | 48.6 |

### 3.2.2 Storage Requirements

The site requires quantity control measures to meet the restrictive stormwater release criteria. It is proposed that an inlet-control device in combination with surface grading (for ponding) and rooftop drain restrictions be used to reduce the peak flow. To provide the necessary controls, surface and roof storage were maximized across the site.

#### 3.2.2.1 Uncontrolled Catchments

Due to grading constraints, one catchment has been designed without a storage component (Uncon). This area flows offsite to the Bachman Terrace ROW uncontrolled. Areas that discharge offsite without entering the proposed stormwater management system must be compensated for in areas with controls. Table 2 summarizes the peak uncontrolled 5 and 100 year catchment release rates for catchments that are released to Bachman Terrace uncontrolled.

Table 2: 5 and 100 Year Discharge From Uncontrolled Catchments

| Catchment ID | 5-Year Peak Discharge (L/s) | 100-Year Peak Discharge (L/s) |
|---|---|---|
| Uncon | 9.2 | 19.7 |

Peak 5 and 100 year discharge values in Table 2 are based on minimum time of concentration values (10 minutes).

#### 3.2.2.2 Rooftop Storage

It is proposed to retain stormwater on the rooftops by installing restricted flow roof drains. The following calculations assume the roof will be equipped with a standard Zurn Model Z-105-5 Control-Flow Single Notch Roof Drain, see Appendix C for details.

Zurn Industries Ltd. "Control-Flo" roof drain data has been used to calculate a practical roof release rate and detention storage volume for the rooftops. It should be noted that the "Control-Flo" roof drain has been used as an example only, and that other products may be specified for use, provided that the roof release rate is restricted to match the maximum rate of release indicated in Table 3 and Table 4 for the rooftops, and that sufficient roof storage is provided to meet (or exceed) the resulting volume of detained stormwater.

Table 3 and Table 4 provide details regarding the retention of stormwater on the proposed rooftops during the 5 and 100 year storm events. Refer to Appendix A for details. Both buildings are tributary to the upstream control (via roof leader) for area A-1 and as such their discharges are further controlled at that location.

### Table 3: Summary of Rooftop Storage (5-Year)

| Location | Depth (mm) | Discharge (L/s) | $V_{required}$ ($m^3$) | Drawdown Time (h) | $V_{available}$ ($m^3$) |
|---|---|---|---|---|---|
| Block 1 | 90 | 2.7 | 7 | 1.1 | 20 |
| Block 2 | 87 | 4.0 | 9 | 0.9 | 26 |
| Block 3 | 72 | 3.3 | 3 | 0.3 | 12 |

1. Buildings 1 and 3 are tributary to the upstream control at A-1.

### Table 4: Summary of Rooftop Storage (100-Year)

| Location | Depth (mm) | Discharge (L/s) | $V_{required}$ ($m^3$) | Drawdown Time (h) | $V_{available}$ ($m^3$) |
|---|---|---|---|---|---|
| Block 1 | 133 | 4.0 | 16 | 1.7 | 20 |
| Block 2 | 129 | 5.9 | 19 | 1.4 | 26 |
| Block 3 | 109 | 5.0 | 7 | 0.5 | 12 |

1. Buildings 1 and 3 are tributary to the upstream control at A-1.

### 3.2.2.3 Surface Storage

In addition to rooftop storage, it is proposed to detain stormwater on the surface in parking and landscape areas. The modified rational method was employed to determine the peak volume stored in surface ponding areas. Inlet control devices were sized based on the available storage volumes during the 5 and 100 year storm events.

Table 5 summarizes the estimated storm release rates and storage volumes during the 5 and 100 events.

### Table 5: 5 and 100 Year Peak Surface Volume and Controlled Discharge Summary

| | | 5-Year Event | | | 100-Year Event | | |
|---|---|---|---|---|---|---|---|
| Tributary Area ID | ICD (mm) | Discharge (L/s) | $V_{required}$ ($m^3$) | $V_{available}$ ($m^3$) | Discharge (L/s) | $V_{required}$ ($m^3$) | $V_{available}$ ($m^3$) |
| A-1 | 135 | 11.6 | 17.4 | 23.4 | 21.2 | 20.7 | 23.4 |

1. 100-year volume available based on surface storage and a maximum spill depth not to exceed 0.30m, where required.

The inlet control device (ICD) was sized with the following orifice equation:

$$Q = C_d A(2gh)^{1/2}$$

Where, $C_d = 0.61$

A = Area of Orifice (m2)

g = 9.81 m/s2
h = design head (m)

The design head used to determine restricted flow rates through the proposed orifices was measured from the downstream water level up to the level of surface ponding in the catchment area. Downstream water levels were considered to be at the obvert of the receiving culvert within the Bachman Terrace ROW. Refer to Appendix A for details.

### 3.2.3 Results

Table 6 demonstrates that the proposed stormwater management plan provides adequate attenuation storage to meet the target peak outflow rates for the site.

#### Table 6: Summary of Total 5 and 100 Year Event Release Rates

| | 5-Year Peak Discharge (L/s) | 100-Year Peak Discharge (L/s) |
|---|---|---|
| Uncontrolled | 9.2 | 19.7 |
| Controlled – Roof | 10.0 | 14.9 |
| Controlled - Surface | 11.6 | 21.2 |
| Total | 24.8 | 46.8 |
| Target | 22.7 | 48.6 |

*Note that roof discharge rates may not be summed directly to the total site peak discharge, as the release rates of Blocks 1 and 3 are included within the controlled surface discharge values due to downstream controls.

## 3.3 WATER QUALITY CONTROL

Conversations with City of Ottawa staff have not identified the need for on-site stormwater quality control measures. As roof leaders and controlled discharge areas are routed to grassed swales at the perimeter of the property, and site drainage is routed in its entirety to grassed swales and culverts within the Bachman Terrace ROW over the entire site frontage, it is assumed that suspended solids within runoff generated by the site will not have a deleterious impact on downstream watercourses (Watt's Creek).

# 4.0 Erosion and Sediment Control

Erosion and sediment controls must be in place during construction. The following recommendations to the contractor will be included in contract documents.

1. Implement best management practices to provide appropriate protection of the existing and proposed drainage system and the receiving water course(s).
2. Limit extent of exposed soils at any given time.
3. Re-vegetate exposed areas as soon as possible.
4. Minimize the area to be cleared and grubbed.
5. Protect exposed slopes with plastic or synthetic mulches.
6. Provide sediment traps and basins during dewatering.
7. Install sediment traps (such as SiltSack® by Terrafix) between catch basins and frames.
8. Plan construction at proper time to avoid flooding.

The contractor will, at every rainfall, complete inspections and guarantee proper performance. The inspection is to include:

9. Verification that water is not flowing under silt barriers.
10. Clean and change silt traps at catch basins.

Refer to Drawing EC-1 for the proposed location of silt fences, straw bales and other erosion control structures.

# 5.0 Conclusions and Recommendations

Based on the preceding report update, the following conclusions can be drawn:

- Quantity control is provided via a combination of rooftop and surface storage.
- The site discharges stormwater to the existing storm sewer infrastructure without exceeding the calculated allowable 100-year release rate.
- 100 year ponding depths have been maintained at a maximum of 0.055 m on rooftops and 0.30 m in surface catchments within parking areas.
- 100 year volumes for controlled catchments are contained on-site.
- Major overland flow paths have been provided to relieve the parking and access areas during emergency conditions or extreme rainfall events.
- Additional stormwater quality control measures are not required.

Based on the findings of the report, the following recommendations are provided:

- The proposed stormwater management measures provided in this report be implemented for the development.

# Appendix A : Modified Rational Method Storage Calculations

Stantec

## Stormwater Management Design Parameters

**5 yr Intensity** $I = a/(t + b)^c$ a = 998.071
**City of Ottawa** b = 6.053
c = 0.814

**5-Year Predevelopment Release Rate**

**Area (ha):** 0.338
**C:** 0.29

| tc (min) | I (5 yr) (mm/hr) | Qactual (L/s) | Qrelease (L/s) | Qstored (L/s) | Vstored ($m^3$) |
|---|---|---|---|---|---|
| 15 | 83.6 | 22.7 | 22.7 | 0.0 | 0.0 |

**100 yr Intensity** $I = a/(t + b)^c$ a = 1735.688
**City of Ottawa** b = 6.014
c = 0.820

**100-Year Predevelopment Release Rate**

**Area (ha):** 0.338
**C:** 0.36

| tc (min) | I (5 yr) (mm/hr) | Qactual (L/s) | Qrelease (L/s) | Qstored (L/s) | Vstored ($m^3$) |
|---|---|---|---|---|---|
| 15 | 142.9 | 48.6 | 48.6 | 0.0 | 0.0 |

**100-yr Target = 48.6 L/s** *Site Runoff + External Runoff

## Proposed Stormwater Management Plan

### Uncontrolled Areas

**Area ID:** Uncon
**Area (ha):** 0.065
**C:** 0.49

| tc (min) | I (5 yr) (mm/hr) | Qactual (L/s) | Qrelease (L/s) | Qstored (L/s) | Vstored ($m^3$) |
|---|---|---|---|---|---|
| 10 | 104.2 | 9.2 | 9.2 | 0.0 | 0.0 |

**Area ID:** Uncon
**Area (ha):** 0.065
**C:** 0.61

| tc (min) | I (100 yr) (mm/hr) | Qactual (L/s) | Qrelease (L/s) | Qstored (L/s) | Vstored ($m^3$) |
|---|---|---|---|---|---|
| 10 | 178.6 | 19.7 | 19.7 | 0.0 | 0.0 |

### Controlled Areas

**Area ID:** A-1
**Area (ha):** 0.126 *All Roof drains from Blocks 1 and 3
**C:** 0.56 tributary to Area A-1

| tc (min) | I (5 yr) (mm/hr) | Qactual (L/s) | Qrelease (L/s) | Qstored (L/s) | Vstored ($m^3$) | |
|---|---|---|---|---|---|---|
| 10 | 104.2 | 30.4 | 11.6 | 18.8 | 11.3 | |
| 15 | 83.6 | 26.4 | 11.6 | 14.8 | 13.3 | |
| 20 | 70.3 | 23.8 | 11.6 | 12.2 | 14.6 | |
| 30 | 53.9 | 20.6 | 11.6 | 9.0 | 16.1 | |
| 40 | 44.2 | 18.6 | 11.6 | 7.0 | 16.9 | |
| 50 | 37.7 | 17.4 | 11.6 | 5.8 | 17.3 | |
| 60 | 32.9 | 16.4 | 11.6 | 4.8 | 17.4 | <-- |
| 70 | 29.4 | 15.7 | 11.6 | 4.1 | 17.4 | |
| 80 | 26.6 | 15.2 | 11.6 | 3.6 | 17.2 | |
| 90 | 24.3 | 14.7 | 11.6 | 3.1 | 17.0 | |
| 100 | 22.4 | 14.4 | 11.6 | 2.8 | 16.7 | |
| 110 | 20.8 | 14.1 | 11.6 | 2.5 | 16.3 | |
| 120 | 19.5 | 13.8 | 11.6 | 2.2 | 15.8 | |
| 130 | 18.3 | 13.6 | 11.6 | 2.0 | 15.4 | |

Orifice Equation: $Q = C_dA(2gh)^{1/2}$ Where C= 0.610
Orifice Diameter: 135 mm
Control Invert Elevation 118.00 m
T/G Elevation: 118.00 m
Downstream W/L: 118.00 m *Obvert of outlet sewer

| Control Location | Ponding Elev.[1] (m) | Head[2] (m) | Discharge[3] (L/s) | $V_{required}$[4] ($m^3$) | $V_{available}$[5] ($m^3$) | Volume Check |
|---|---|---|---|---|---|---|
| A-1 | 118.09 | 0.09 | 11.6 | 17.4 | 23.4 | ok |

**Area ID:** A-1
**Area (ha):** 0.126 *All Roof drains from Blocks 1 and 3
**C:** 0.70 tributary to Area A-1

| tc (min) | I (100 yr) (mm/hr) | Qactual (L/s) | Qrelease (L/s) | Qstored (L/s) | Vstored ($m^3$) | |
|---|---|---|---|---|---|---|
| 10 | 178.6 | 52.8 | 21.2 | 31.6 | 18.9 | |
| 15 | 142.9 | 44.0 | 21.2 | 22.8 | 20.6 | |
| 20 | 120.0 | 38.4 | 21.2 | 17.2 | 20.7 | <-- |
| 30 | 91.9 | 31.5 | 21.2 | 10.3 | 18.6 | |
| 40 | 75.1 | 27.4 | 21.2 | 6.2 | 15.0 | |
| 50 | 64.0 | 24.7 | 21.2 | 3.5 | 10.5 | |
| 60 | 55.9 | 22.7 | 21.2 | 1.5 | 5.5 | |
| 70 | 49.8 | 21.2 | 21.2 | 0.0 | 0.1 | |
| 80 | 45.0 | 20.0 | 20.0 | 0.0 | 0.0 | |
| 90 | 41.1 | 19.1 | 19.1 | 0.0 | 0.0 | |
| 100 | 37.9 | 18.3 | 18.3 | 0.0 | 0.0 | |
| 110 | 35.2 | 17.6 | 17.6 | 0.0 | 0.0 | |
| 120 | 32.9 | 17.1 | 17.1 | 0.0 | 0.0 | |
| 130 | 30.9 | 16.6 | 16.6 | 0.0 | 0.0 | |

Orifice Equation: $Q = C_dA(2gh)^{1/2}$ Where C= 0.610
Orifice Diameter: 135 mm
Control Invert Elevation 118.00 m
T/G Elevation: 118.00 m
Downstream W/L: 118.00 m *Obvert of outlet sewer

| Control Location | Ponding Elev.[1] (m) | Head[2] (m) | Discharge[3] (L/s) | $V_{required}$[4] ($m^3$) | $V_{available}$[5] ($m^3$) | Volume Check |
|---|---|---|---|---|---|---|
| A-1 | 118.30 | 0.30 | 21.2 | 20.7 | 23.4 | ok |

**Inlet Control Notes:**
*1. Max allowable water depth during storm event*
*2. Based on the difference between the 'Storage Depth' less the greater of either the 'Orifice Invert Elevation' or 'Downstream W/L'*
*3. Based on the orifice equation as shown above.*
*4. Volume required per Modified Rational Method.*
*5. Volume available as illustrated on dwg SD-1.*

### Roof Control Areas

| Area (ha) | Depth (mm) | Discharge (L/s) | Vreq ($m^3$) | Est. Drawdown | Vavail ($m^3$) |
|---|---|---|---|---|---|
| 0.051 | 90 | 2.7 | 7 | 1.1 | 20 |

| Area (ha) | Depth (mm) | Discharge (L/s) | Vreq ($m^3$) | Est. Drawdown | Vavail ($m^3$) |
|---|---|---|---|---|---|
| 0.065 | 87 | 4.0 | 9 | 0.9 | 26 |

| Area (ha) | Depth (mm) | Discharge (L/s) | Vreq ($m^3$) | Est. Drawdown | Vavail ($m^3$) |
|---|---|---|---|---|---|
| 0.031 | 72 | 3.3 | 3 | 0.3 | 12 |

| Area (ha) | Depth (mm) | Discharge (L/s) | Vreq ($m^3$) | Est. Drawdown | Vavail ($m^3$) |
|---|---|---|---|---|---|
| 0.051 | 133 | 4.0 | 16 | 1.7 | 20 |

| Area (ha) | Depth (mm) | Discharge (L/s) | Vreq ($m^3$) | Est. Drawdown | Vavail ($m^3$) |
|---|---|---|---|---|---|
| 0.065 | 129 | 5.9 | 19 | 1.4 | 26 |

| Area (ha) | Depth (mm) | Discharge (L/s) | Vreq ($m^3$) | Est. Drawdown | Vavail ($m^3$) |
|---|---|---|---|---|---|
| 0.031 | 109 | 5.0 | 7 | 0.5 | 12 |

## Estimated Discharge from Site

Total Uncontrolled Area 0.065 ha
5-year Uncontrolled Release 9.2 L/s

Total Controlled Area 0.126 ha
Storage Volume 17.4 $m^3$
5-year Controlled Release 11.6 L/s

Total Controlled Roof Area 0.147 ha
Roof Storage Volume 19.3 $m^3$
5-year Controlled Roof Release 10.0 L/s

**Total Area 0.338 ha**
**Total Volume Retained 37 $m^3$**
**Total 5-year Release 24.8 L/s**

Total Uncontrolled Area 0.065 ha
100-year Uncontrolled Release 19.7 L/s

Total Controlled Area 0.126 ha
Storage Volume 20.7 $m^3$
100-year Controlled Release 21.2 L/s

Total Controlled Roof Area 0.147 ha
Roof Storage Volume 42.1 $m^3$
100-year Controlled Roof Release 14.9 L/s

**Total Area 0.338 ha**
**Total Volume Retained 63 $m^3$**
**Total 100-year Release 46.8 L/s**

## Proposed Bachman Terrace Building (Block 1)

| Rating Curve | | | | Volume Estimation (Conical) | | | | |
|---|---|---|---|---|---|---|---|---|
| Elevation (m) | Discharge Rate ($m^3/s$) | Outlet Discharge ($m^3/s$) | Storage ($m^3$) | Elevation (m) | Area ($m^2$) | Volume ($m^3$) Increment | Volume ($m^3$) Accumulated | Water Depth (m) |
| 0.000 | 0.0000 | 0.0000 | 0.0 | 0.000 | 0 | 0 | 0 | 0.000 |
| 0.025 | 0.0004 | 0.0008 | 0.6 | 0.025 | 68 | 0.6 | 0.6 | 0.025 |
| 0.050 | 0.0008 | 0.0015 | 2.3 | 0.050 | 136 | 1.7 | 2.3 | 0.050 |
| 0.075 | 0.0011 | 0.0023 | 5.1 | 0.075 | 204 | 2.8 | 5.1 | 0.075 |
| 0.100 | 0.0015 | 0.0030 | 9.1 | 0.100 | 272 | 4.0 | 9.1 | 0.100 |
| 0.125 | 0.0019 | 0.0038 | 14.2 | 0.125 | 340 | 5.1 | 14.2 | 0.125 |
| 0.150 | 0.0023 | 0.0046 | 20.4 | 0.150 | 408 | 6.2 | 20.4 | 0.150 |

**Drawdown Estimate**

| Total Volume ($m^3$) | Total Time (sec) | Vol ($m^3$) | Detention Time (hr) |
|---|---|---|---|
| 0.6 | 746 | 0.6 | 0.2 |
| 2.3 | 1,104 | 1.7 | 0.5 |
| 5.1 | 1,243 | 2.8 | 0.9 |
| 9.1 | 1,305 | 4.0 | 1.2 |
| 14.2 | 1,342 | 5.1 | 1.6 |
| 20.4 | 1,367 | 6.2 | 2.0 |

| Roof-top Storage Summary | | |
|---|---|---|
| Total Building Area (ha) | | 0.051 |
| Total Building Area ($m^2$) | | 510 |
| Assume Available Roof Area ($m^2$) | 80% | 408 |
| Roof Imperviousness | | 100% |
| Roof Drain Requirement ($m^2$/notch) | | 232 |
| Number of Roof Notches* | | 2 |
| Maximum Allowable Depth of Roof Ponding (m) | | 0.15 |
| Maximum Available Storage ($m^3$) | | 20 |
| Estimated 100 Year Drawdown Time (h) | | 1.7 |

* Note: Number of drains can be reduced if multiple-notch drain used

**Modelling Results**

| | 5yr | 100yr | Available |
|---|---|---|---|
| Qresult ($m^3/s$) | 0.0027 | 0.0040 | - |
| Depth (m) | 0.090 | 0.133 | 0.15 |
| Volume ($m^3$) | 7 | 16 | 20 |
| Draintime (hrs) | 1.1 | 1.7 | - |

### Modified Rational Method Calculations

**5 yr Intensity** $I = a/(t + b)^c$ a = 998.071
**City of Ottawa** b = 6.053
c = 0.814

**Area (ha):** 0.051
**C:** 0.90

| tc (min) | I (5 yr) (mm/hr) | Qactual (L/s) | Qrelease (L/s) | Qstored (L/s) | Vstored ($m^3$) |
|---|---|---|---|---|---|
| 10 | 104.2 | 13.3 | 2.7 | 10.6 | 6.3 |
| 15 | 83.6 | 10.7 | 2.7 | 7.9 | 7.1 |
| 20 | 70.3 | 9.0 | 2.7 | 6.2 | 7.5 |
| 30 | 53.9 | 6.9 | 2.7 | 4.1 | 7.5 |
| 40 | 44.2 | 5.6 | 2.7 | 2.9 | 7.0 |
| 50 | 37.7 | 4.8 | 2.7 | 2.1 | 6.2 |
| 60 | 32.9 | 4.2 | 2.7 | 1.5 | 5.3 |
| 70 | 29.4 | 3.7 | 2.7 | 1.0 | 4.3 |
| 80 | 26.6 | 3.4 | 2.7 | 0.7 | 3.1 |
| 90 | 24.3 | 3.1 | 2.7 | 0.4 | 2.0 |
| 100 | 22.4 | 2.9 | 2.7 | 0.1 | 0.7 |
| 110 | 20.8 | 2.7 | 2.7 | 0.0 | 0.0 |
| 120 | 19.5 | 2.5 | 2.5 | 0.0 | 0.0 |
| 130 | 18.3 | 2.3 | 2.3 | 0.0 | 0.0 |
| 140 | 17.3 | 2.2 | 2.2 | 0.0 | 0.0 |

| | Depth (mm) | Head (m) | Discharge (L/s) | Vreq ($m^3$) | Vavail ($m^3$) | Discharge Check |
|---|---|---|---|---|---|---|
| 5-year Water Level | 90 | 0.090 | 2.74 | 7 | 20 | 0.0 |

**100 yr Intensity** $I = a/(t + b)^c$ a = 1735.688
**City of Ottawa** b = 6.014
c = 0.820

**Area (ha):** 0.051
**C:** 1.00

| tc (min) | I (100 yr) (mm/hr) | Qactual (L/s) | Qrelease (L/s) | Qstored (L/s) | Vstored ($m^3$) |
|---|---|---|---|---|---|
| 10 | 178.6 | 25.3 | 4.0 | 21.3 | 12.8 |
| 15 | 142.9 | 20.3 | 4.0 | 16.2 | 14.6 |
| 20 | 120.0 | 17.0 | 4.0 | 13.0 | 15.6 |
| 30 | 91.9 | 13.0 | 4.0 | 9.0 | 16.2 |
| 40 | 75.1 | 10.7 | 4.0 | 6.6 | 15.9 |
| 50 | 64.0 | 9.1 | 4.0 | 5.0 | 15.1 |
| 60 | 55.9 | 7.9 | 4.0 | 3.9 | 14.0 |
| 70 | 49.8 | 7.1 | 4.0 | 3.0 | 12.7 |
| 80 | 45.0 | 6.4 | 4.0 | 2.3 | 11.2 |
| 90 | 41.1 | 5.8 | 4.0 | 1.8 | 9.7 |
| 100 | 37.9 | 5.4 | 4.0 | 1.3 | 8.0 |
| 110 | 35.2 | 5.0 | 4.0 | 1.0 | 6.3 |
| 120 | 32.9 | 4.7 | 4.0 | 0.6 | 4.5 |
| 130 | 30.9 | 4.4 | 4.0 | 0.3 | 2.7 |
| 140 | 29.2 | 4.1 | 4.0 | 0.1 | 0.8 |

| | Depth (mm) | Head (m) | Discharge (L/s) | Vreq ($m^3$) | Vavail ($m^3$) | Discharge Check |
|---|---|---|---|---|---|---|
| 100-year Water Level | 133 | 0.133 | 4.04 | 16 | 20 | 0.0 |

Stantec

## Proposed Bachman Terrace Building (Block 2)

| Rating Curve | | | | Volume Estimation (Conical) | | | | |
|---|---|---|---|---|---|---|---|---|
| Elevation | Discharge Rate | Outlet Discharge | Storage | Elevation | Area | Volume ($m^3$) | | Water Depth |
| (m) | ($m^3$/s) | ($m^3$/s) | ($m^3$) | (m) | ($m^2$) | Increment | Accumulated | (m) |
| 0.000 | 0.0000 | 0.0000 | 0.0 | 0.000 | 0 | 0 | 0 | 0.000 |
| 0.025 | 0.0004 | 0.0011 | 0.7 | 0.025 | 87 | 0.7 | 0.7 | 0.025 |
| 0.050 | 0.0008 | 0.0023 | 2.9 | 0.050 | 173 | 2.2 | 2.9 | 0.050 |
| 0.075 | 0.0011 | 0.0034 | 6.5 | 0.075 | 260 | 3.6 | 6.5 | 0.075 |
| 0.100 | 0.0015 | 0.0046 | 11.6 | 0.100 | 347 | 5.1 | 11.6 | 0.100 |
| 0.125 | 0.0019 | 0.0057 | 18.1 | 0.125 | 433 | 6.5 | 18.1 | 0.125 |
| 0.150 | 0.0023 | 0.0068 | 26.0 | 0.150 | 520 | 7.9 | 26.0 | 0.150 |

**Drawdown Estimate**

| Total Volume ($m^3$) | Total Time (sec) | Vol ($m^3$) | Detention Time (hr) |
|---|---|---|---|
| 0.7 | 634 | 0.7 | 0.2 |
| 2.9 | 938 | 2.2 | 0.4 |
| 6.5 | 1,056 | 3.6 | 0.7 |
| 11.6 | 1,109 | 5.1 | 1.0 |
| 18.1 | 1,140 | 6.5 | 1.4 |
| 26.0 | 1,161 | 7.9 | 1.7 |

| Roof-top Storage Summary | | |
|---|---|---|
| Total Building Area (ha) | | 0.065 |
| Total Building Area ($m^2$) | | 650 |
| Assume Available Roof Area ($m^2$) | 80% | 520 |
| Roof Imperviousness | | 100% |
| Roof Drain Requirement ($m^2$/notch) | | 232 |
| Number of Roof Notches* | | 3 |
| Maximum Allowable Depth of Roof Ponding (m) | | 0.15 |
| Maximum Available Storage ($m^3$) | | 26 |
| Estimated 100 Year Drawdown Time (h) | | 1.4 |

* Note: Number of drains can be reduced if multiple-notch drain used

**Modelling Results**

| | 5yr | 100yr | Available |
|---|---|---|---|
| Qresult ($m^3$/s) | 0.0040 | 0.0059 | - |
| Depth (m) | 0.087 | 0.129 | 0.15 |
| Volume ($m^3$) | 9 | 19 | 26 |
| Draintime (hrs) | 0.9 | 1.4 | - |

### Modified Rational Method Calculations

**5 yr Intensity** $I = a/(t + b)^c$ a = 998.071, b = 6.053, c = 0.814
**City of Ottawa**

**Area (ha):** 0.065
**C:** 0.90

| tc (min) | I (5 yr) (mm/hr) | Qactual (L/s) | Qrelease (L/s) | Qstored (L/s) | Vstored ($m^3$) |
|---|---|---|---|---|---|
| 10 | 104.2 | 16.9 | 4.0 | 13.0 | 7.8 |
| 15 | 83.6 | 13.6 | 4.0 | 9.6 | 8.7 |
| 20 | 70.3 | 11.4 | 4.0 | 7.5 | 8.9 |
| 30 | 53.9 | 8.8 | 4.0 | 4.8 | 8.6 |
| 40 | 44.2 | 7.2 | 4.0 | 3.2 | 7.7 |
| 50 | 37.7 | 6.1 | 4.0 | 2.2 | 6.5 |
| 60 | 32.9 | 5.4 | 4.0 | 1.4 | 5.0 |
| 70 | 29.4 | 4.8 | 4.0 | 0.8 | 3.4 |
| 80 | 26.6 | 4.3 | 4.0 | 0.3 | 1.7 |
| 90 | 24.3 | 4.0 | 4.0 | 0.0 | 0.0 |
| 100 | 22.4 | 3.6 | 3.6 | 0.0 | 0.0 |
| 110 | 20.8 | 3.4 | 3.4 | 0.0 | 0.0 |
| 120 | 19.5 | 3.2 | 3.2 | 0.0 | 0.0 |
| 130 | 18.3 | 3.0 | 3.0 | 0.0 | 0.0 |
| 140 | 17.3 | 2.8 | 2.8 | 0.0 | 0.0 |

| | Depth (mm) | Head (m) | Discharge (L/s) | Vreq ($m^3$) | Vavail ($m^3$) | Discharge Check |
|---|---|---|---|---|---|---|
| 5-year Water Level | 87 | 0.087 | 3.97 | 9 | 26 | 0.0 |

**100 yr Intensity** $I = a/(t + b)^c$ a = 1735.688, b = 6.014, c = 0.820
**City of Ottawa**

**Area (ha):** 0.065
**C:** 1.00

| tc (min) | I (100 yr) (mm/hr) | Qactual (L/s) | Qrelease (L/s) | Qstored (L/s) | Vstored ($m^3$) |
|---|---|---|---|---|---|
| 10 | 178.6 | 32.3 | 5.9 | 26.4 | 15.8 |
| 15 | 142.9 | 25.8 | 5.9 | 19.9 | 17.9 |
| 20 | 120.0 | 21.7 | 5.9 | 15.8 | 19.0 |
| 30 | 91.9 | 16.6 | 5.9 | 10.7 | 19.3 |
| 40 | 75.1 | 13.6 | 5.9 | 7.7 | 18.5 |
| 50 | 64.0 | 11.6 | 5.9 | 5.7 | 17.0 |
| 60 | 55.9 | 10.1 | 5.9 | 4.2 | 15.2 |
| 70 | 49.8 | 9.0 | 5.9 | 3.1 | 13.1 |
| 80 | 45.0 | 8.1 | 5.9 | 2.2 | 10.8 |
| 90 | 41.1 | 7.4 | 5.9 | 1.5 | 8.4 |
| 100 | 37.9 | 6.8 | 5.9 | 1.0 | 5.8 |
| 110 | 35.2 | 6.4 | 5.9 | 0.5 | 3.2 |
| 120 | 32.9 | 5.9 | 5.9 | 0.1 | 0.5 |
| 130 | 30.9 | 5.6 | 5.6 | 0.0 | 0.0 |
| 140 | 29.2 | 5.3 | 5.3 | 0.0 | 0.0 |

| | Depth (mm) | Head (m) | Discharge (L/s) | Vreq ($m^3$) | Vavail ($m^3$) | Discharge Check |
|---|---|---|---|---|---|---|
| 100-year Water Level | 129 | 0.129 | 5.88 | 19 | 26 | 0.0 |

## Proposed Bachman Terrace Building (Block 3)

| Rating Curve | | | | Volume Estimation (Conical) | | | | |
|---|---|---|---|---|---|---|---|---|
| Elevation (m) | Discharge Rate ($m^3/s$) | Outlet Discharge ($m^3/s$) | Storage ($m^3$) | Elevation (m) | Area ($m^2$) | Volume ($m^3$) Increment | Volume ($m^3$) Accumulated | Water Depth (m) |
| 0.000 | 0.0000 | 0.0000 | 0.0 | 0.000 | 0 | 0 | 0 | 0.000 |
| 0.025 | 0.0004 | 0.0011 | 0.3 | 0.025 | 41 | 0.3 | 0.3 | 0.025 |
| 0.050 | 0.0008 | 0.0023 | 1.4 | 0.050 | 83 | 1.0 | 1.4 | 0.050 |
| 0.075 | 0.0011 | 0.0034 | 3.1 | 0.075 | 124 | 1.7 | 3.1 | 0.075 |
| 0.100 | 0.0015 | 0.0046 | 5.5 | 0.100 | 165 | 2.4 | 5.5 | 0.100 |
| 0.125 | 0.0019 | 0.0057 | 8.6 | 0.125 | 207 | 3.1 | 8.6 | 0.125 |
| 0.150 | 0.0023 | 0.0068 | 12.4 | 0.150 | 248 | 3.8 | 12.4 | 0.150 |

**Drawdown Estimate**

| Total Volume ($m^3$) | Total Time (sec) | Vol ($m^3$) | Detention Time (hr) |
|---|---|---|---|
| 0.3 | 302 | 0.3 | 0.1 |
| 1.4 | 447 | 1.0 | 0.2 |
| 3.1 | 504 | 1.7 | 0.3 |
| 5.5 | 529 | 2.4 | 0.5 |
| 8.6 | 544 | 3.1 | 0.6 |
| 12.4 | 554 | 3.8 | 0.8 |

**Roof-top Storage Summary**

| | | |
|---|---|---|
| Total Building Area (ha) | | 0.031 |
| Total Building Area ($m^2$) | | 310 |
| Assume Available Roof Area ($m^2$) | 80% | 248 |
| Roof Imperviousness | | 100% |
| Roof Drain Requirement ($m^2$/notch) | | 232 |
| Number of Roof Notches* | | 3 |
| Maximum Allowable Depth of Roof Ponding (m) | | 0.15 |
| Maximum Available Storage ($m^3$) | | 12 |
| Estimated 100 Year Drawdown Time (h) | | 0.5 |

* Note: Number of drains can be reduced if multiple-notch drain used

**Modelling Results**

| | 5yr | 100yr | Available |
|---|---|---|---|
| Qresult ($m^3/s$) | 0.0033 | 0.0050 | - |
| Depth (m) | 0.072 | 0.109 | 0.15 |
| Volume ($m^3$) | 3 | 7 | 12 |
| Draintime (hrs) | 0.3 | 0.5 | - |

### Modified Rational Method Calculations

**5 yr Intensity** $I = a/(t + b)^c$ a = 998.071
**City of Ottawa** b = 6.053
c = 0.814

**Area (ha):** 0.031
**C:** 0.90

| tc (min) | I (5 yr) (mm/hr) | Qactual (L/s) | Qrelease (L/s) | Qstored (L/s) | Vstored ($m^3$) |
|---|---|---|---|---|---|
| 10 | 104.2 | 8.1 | 3.3 | 4.8 | 2.9 |
| 15 | 83.6 | 6.5 | 3.3 | 3.2 | 2.9 |
| 20 | 70.3 | 5.4 | 3.3 | 2.2 | 2.6 |
| 30 | 53.9 | 4.2 | 3.3 | 0.9 | 1.6 |
| 40 | 44.2 | 3.4 | 3.3 | 0.2 | 0.4 |
| 50 | 37.7 | 2.9 | 2.9 | 0.0 | 0.0 |
| 60 | 32.9 | 2.6 | 2.6 | 0.0 | 0.0 |
| 70 | 29.4 | 2.3 | 2.3 | 0.0 | 0.0 |
| 80 | 26.6 | 2.1 | 2.1 | 0.0 | 0.0 |
| 90 | 24.3 | 1.9 | 1.9 | 0.0 | 0.0 |
| 100 | 22.4 | 1.7 | 1.7 | 0.0 | 0.0 |
| 110 | 20.8 | 1.6 | 1.6 | 0.0 | 0.0 |
| 120 | 19.5 | 1.5 | 1.5 | 0.0 | 0.0 |
| 130 | 18.3 | 1.4 | 1.4 | 0.0 | 0.0 |
| 140 | 17.3 | 1.3 | 1.3 | 0.0 | 0.0 |

| | Depth (mm) | Head (m) | Discharge (L/s) | Vreq ($m^3$) | Vavail ($m^3$) | Discharge Check |
|---|---|---|---|---|---|---|
| 5-year Water Level | 72 | 0.072 | 3.28 | 3 | 12 | 0.0 |

**100 yr Intensity** $I = a/(t + b)^c$ a = 1735.688
**City of Ottawa** b = 6.014
c = 0.820

**Area (ha):** 0.031
**C:** 1.00

| tc (min) | I (100 yr) (mm/hr) | Qactual (L/s) | Qrelease (L/s) | Qstored (L/s) | Vstored ($m^3$) |
|---|---|---|---|---|---|
| 10 | 178.6 | 15.4 | 5.0 | 10.4 | 6.3 |
| 15 | 142.9 | 12.3 | 5.0 | 7.3 | 6.6 |
| 20 | 120.0 | 10.3 | 5.0 | 5.4 | 6.4 |
| 30 | 91.9 | 7.9 | 5.0 | 3.0 | 5.3 |
| 40 | 75.1 | 6.5 | 5.0 | 1.5 | 3.6 |
| 50 | 64.0 | 5.5 | 5.0 | 0.5 | 1.6 |
| 60 | 55.9 | 4.8 | 4.8 | 0.0 | 0.0 |
| 70 | 49.8 | 4.3 | 4.3 | 0.0 | 0.0 |
| 80 | 45.0 | 3.9 | 3.9 | 0.0 | 0.0 |
| 90 | 41.1 | 3.5 | 3.5 | 0.0 | 0.0 |
| 100 | 37.9 | 3.3 | 3.3 | 0.0 | 0.0 |
| 110 | 35.2 | 3.0 | 3.0 | 0.0 | 0.0 |
| 120 | 32.9 | 2.8 | 2.8 | 0.0 | 0.0 |
| 130 | 30.9 | 2.7 | 2.7 | 0.0 | 0.0 |
| 140 | 29.2 | 2.5 | 2.5 | 0.0 | 0.0 |

| | Depth (mm) | Head (m) | Discharge (L/s) | Vreq ($m^3$) | Vavail ($m^3$) | Discharge Check |
|---|---|---|---|---|---|---|
| 100-year Water Level | 109 | 0.109 | 4.97 | 7 | 12 | 0.0 |

# Appendix B : Culvert Design Sheet

| SITE: BACHMAN TERRACE | | STORM DESIGN SHEET (City of Ottawa) | DESIGN PARAMETERS |
|---|---|---|---|
| REVISION DATE: | | | DESIGN STORM: **1 in 50 Years(Culverts)** |
| DATE: | 6/4/2015 | | $I = a / (t^c + b)^c$ |
| DESIGNED BY: | SGG | FILE: 160401069 | a= 1569.58; MANNING'S n = 0.024 CMP (unpaved) |
| CHECKED BY: | DCT | | b= 6.014; TIME OF ENTRY 10 min |
| | | | c= 0.8200 |

| LOCATION | | | DRAINAGE AREA | | | | | | | | CULVERT PROPERTIES | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STREET | FROM | TO | AREA (ha) | C | ACCUM. AREA | A x C (ha) | ACCUM. AxC (ha) | T of C (min) | I (mm/h) | Q* (l/s) | LENGTH (m) | Pipe Size (mm) | MATERIAL | SLOPE % | $Q_{CAP}$ (FULL) (L/s) | $Q_{ACT}$ / $Q_{CAP}$ % FULL | VELOCITY (m/s) | TIME OF FLOW (min) |
| Bachman Terrace | A | B | 0.185 | 0.55 | 0.185 | 0.10 | 0.102 | 10.00<br>10.30 | 161.47 | **51.52** | 8.0 | 400.0 | CSP | 0.25 | 56.40 | 91.34% | 0.45 | 0.30 |

*NOTE: Peak flow rate includes 5.88L/s max roof release rate from Block 2

# Appendix C : Zurn Roof Drain Data

# ZURN CONTROL-FLO

## ROOF DRAINAGE SYSTEM

ZURN | a step ahead of tomorrow

## THE ZURN "CONTROL-FLO CONCEPT"

Originally, Zurn introduced the scientifically-advanced "Control-Flo" drainage principle for dead-level roofs. Today, after thousands of successful applications in modern, large dead-level roof areas, Zurn engineers have adapted the comprehensive "Control-Flo" data to **sloped roof** areas.

## WHAT IS "CONTROL-FLO"?

It is an advanced method of removing rain water off dead-level or sloped roofs. As contrasted with conventional drainage practices, which attempt to drain off storm water as quickly as it falls on the roof's surface, "Control-Flo" drains the roof at a controlled rate. Excess water accumulates on the roof under controlled conditions . . . then drains off at a lower rate after a storm abates.

## CUTS DRAINAGE COSTS

Fewer roof drains, smaller diameter piping, smaller sewer sizes, and lower installation costs are possible with a "Control-Flo" drainage system because roof areas are utilized as temporary storage reservoirs.

## REDUCES PROBABILITY OF STORM DAMAGE

Lightens load on combination sewers by reducing rate of water drained from roof tops during severe storms thereby reducing probability of flooded sewers, and consequent backflow into basements and other low areas.

## THANKS TO EXCLUSIVE ZURN "AQUA-WEIR" ACTION

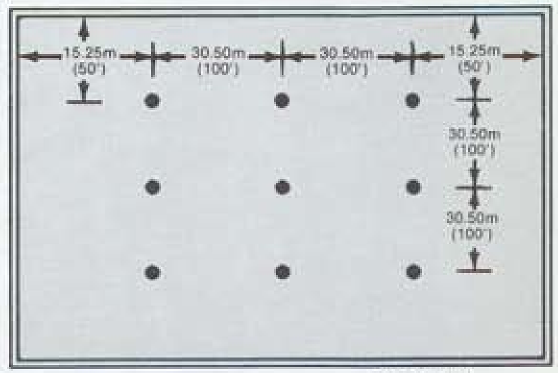
Key to successful "Control-Flo" drainage is a unique, scientifically-designed weir containing accurately calibrated notches with sides formed by parabolic curves which provide flow rates directly proportional to the head. Shape and size of notches are based on predetermined flow rates, and all factors involved in roof drainage to assure permanent regulation of drainage flow rates for specific geographic locations and rainfall intensities.

## DEFINITION

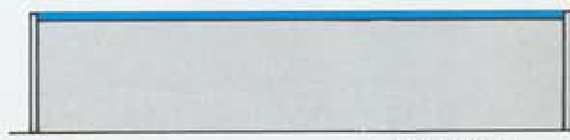
## DEAD LEVEL ROOFS

**DIAGRAM "A"**

A dead-level roof for purposes of applying the Zurn "Control-Flo" drainage principle is one which has been designed for zero slope across its entire surface. Measurements shown are for maximum distances.




(Plan View)



(Section View)

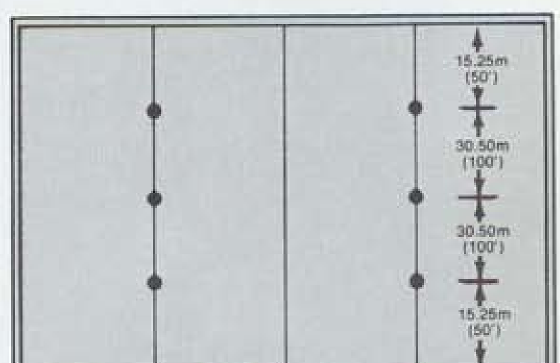
## SLOPED ROOFS

**DIAGRAM "B"**

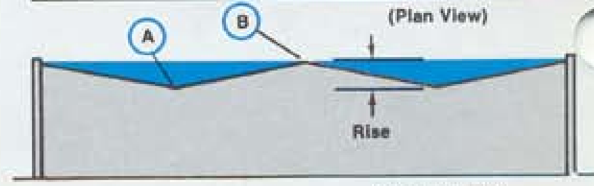
A sloped roof is one designed commonly with a shallow slope. The Zurn "Control-Flo" drainage system can be applied to any slope which results in a total rise up to 152mm(6").

The total rise of a roof as calculated for "Control-Flo" application is defined as the vertical increase in height in inches, from the low point or valley of a sloping roof (A) to the top of the sloping section (B). (Example: a roof that slopes 3mm(1/8") per foot having a 7.25m(24') span would have a rise of 7.25m x 3mm or 76mm (24' x 1/8" or 3")).

Measurements shown are for maximum distances.




(Plan View)

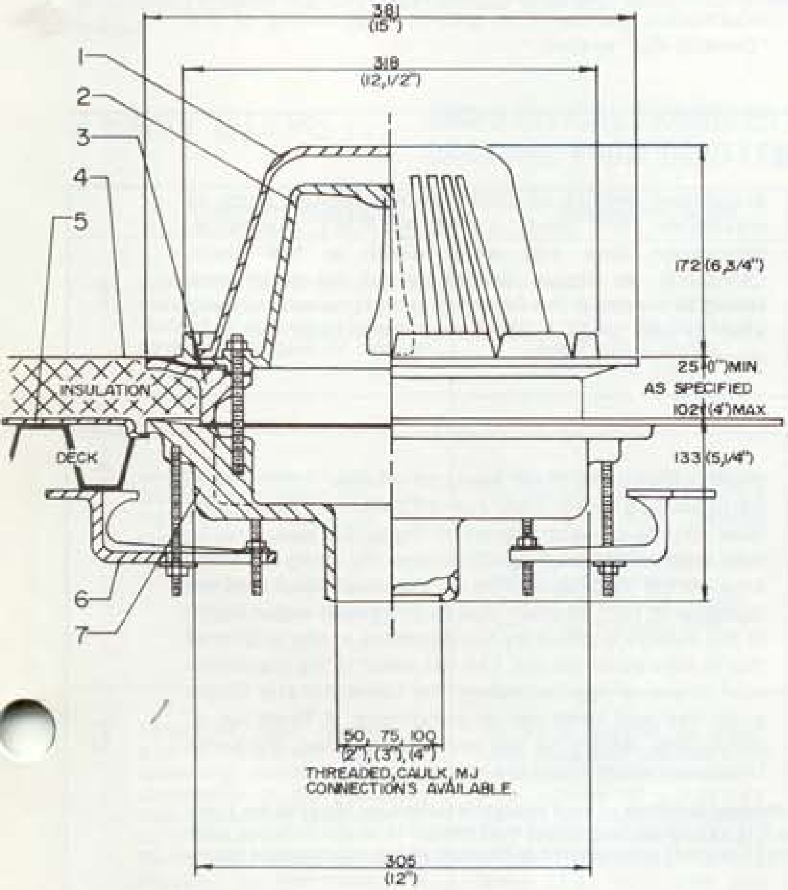



(Section View)

**Dimensions and other measurements given in metric and imperial forms.**

# Economical Roof Drainage Installations

## SPECIFICATION DATA




| PART | DESCRIPTION |
|---|---|
| 1 | POLY-DOME |
| 2 | CONTROL FLO WEIR WITH INTEGRAL CLAMP COLLAR AND GRAVEL GUARD |
| 3 | E-EXTENSION WITH GASKET (WHEN SPECIFIED) |
| 4 | ROOFING MEMBRANE (BY OTHERS) |
| 5 | R-ROOF SUMP RECEIVER (WHEN SPECIFIED) |
| 6 | C-UNDERDECK CLAMP (WHEN SPECIFIED) |
| 7 | BODY |

Z-105-5-ERC "Control-Flo" Dura-Coated Cast Iron Body, Aluminum Parabolic Weir With Integral Clamping Collar And Gravel Guard, Poly Dome. Extension, Roof Sump Receiver, Under Deck Clamp, Aluminum Dome Available When Specified.

## ROOF DESIGN RECOMMENDATIONS

Basic roofing design should incorporate protection that will prevent roof overloading by installing adequate overflow scuppers in parapet walls.

## GENERAL INFORMATION

The "Control-Flo" roof drainage data is tabulated for four areas (232.25m²(2500 sq. ft.), 464.50m²(5000 sq. ft.), 696.75m²(7500 sq. ft.), 929m²(10,000 sq. ft.) notch areas ratings) for each locality. For each notch area rating the maximum discharge in L.P.M.(G.P.M.) — draindown in hours, and maximum water depth at the drain in inches for a dead level roof — 51mm(2 inch) rise — 102mm(4 inch) rise and 152mm(6 inch) rise — are tabulated. The rise is the total change in elevation from the valley to the peak. Values for areas, rise or combination thereof other than those listed, can be arrived at by extrapolation. All data listed is based on the fifty-year return frequency storm. In other words the maximum conditions as listed will occur on the average of once every fifty years.

**NOTE:** The tabulated "Control-Flo" data enables the individual engineer to select his own design limiting condition. The limiting condition can be draindown time, roof load factor, or maximum water depth at the drain. If draindown time is the limiting factor because of possible freezing conditions, it must be recognized that the maximum time listed will occur on the average of once every 50 years and would most likely be during a heavy summer thunder storm. Average winter drain down times would be much shorter in duration than those listed.

## GENERAL RECOMMENDATIONS

On sloping roofs, we recommend a design depth referred to as an equivalent depth. An equivalent depth is the depth of water attained at the drains that results in the same roof stresses as those realized on a dead-level roof. In all cases this equivalent depth is almost equal to that attained by using the same notch area rating for the different rises to 152mm(6"). With the same depth of water at the drain the roof stresses will decrease with increasing total rise. Therefore, it would be possible to have a depth in excess of 152mm(6") at the drain on a sloping roof without exceeding stresses normally encountered in a 152mm(6") depth on a dead-level roof. However, it is recommended that scuppers be placed to limit the maximum water depth on any roof to 152mm(6") to prevent the overflow of the weirs on the drains and consequent overloading of drain piping. In the few cases where the data shows a flow rate in excess of 136 L.P.M.(30 G.P.M.) if all drains and drain lines are sized according to recommendations, and the one storm in fifty years occurs, the only consequence will be a brief flow through the scuppers or over-flow drains.

**NOTE:** An equivalent depth is that depth of water attained at the drains at the lowest line or valley of the roof with all other conditions such as notch area and rainfall intensity being equal. For Toronto, Ontario a notch area rating of 464.50m²(5,000 square feet) results in a 74mm(2.9 inch) depth on a dead level roof for a 50-year storm. For the same notch area and conditions, equivalent depths for a 51mm(2"), 102mm(4") and 152mm(6") rise respectively on a sloped roof would be 86mm(3.4"), 104mm(4.1") and 124mm(4.9"). Roof stresses will be approximately equal in all cases.

The exclusive Zurn "Selecta-Drain" Chart (pages 8, 9, 10, 11) tabulates selection data for 34 localities in Canada. Proper use of this chart consitutes your best assurance of sure, safe, economical application of Zurn "Control-Flo" systems for your specific geographical area. If the "Selecta-Drain" Chart does not cover your specific design criteria, contact Zurn Drainage and Control Systems Ltd., Weston, Ontario, for additional data for your locality. Listed below is additional information pertinent to proper engineering of the "Control-Flo" system.

## ROOF USED AS TEMPORARY RETENTION

The key to economical "Control-Flo" is the utilization of large roof areas to temporarily store the maximum amount of water without overloading average roofs or creating excessive draindown time during periods of heavy rainfall. The data shown in the "Selecta-Drain" Chart enables the engineer to select notch area ratings from 232.25m²(2,500 ft.²) to 929m²(10,000 ft.²) and to accurately predict all other design factors such as maximum roof load, L.P.M. (G.P.M.) discharge, draindown time and water depth at the drain. Obviously, as design factors permit the notch area rating to increase the resulting money saved in being able to use small leaders and drain lines will also increase.

## ROOF LOADING AND RUN-OFF RATES

The four values listed in the "Selecta-Drain" Chart for notch area ratings for different localities will normally span the range of good design. If areas per notch below 232.25m²(2,500 ft.²) are used considerable economy of the "Control-Flo" concept is being lost. The area per notch is limited to 929m²(10,000 square feet) to keep the draindown time within reasonable limits. Extensive studies show that stresses due to water load on a sloping roof for any fixed set of conditions are very nearly the same as those on a dead-level roof. A sloping roof tends to concentrate more water in the valleys and increase the water depth at this point. The greater depth around the drain leads to a faster run-off rate, particularly a faster early run-off rate. As a result, the total volume of water stored on the roof is less, and the total load on the sloping roof is less. By using the same area on the sloping roof as on the dead-level roof the increase in roof stresses due to increased water depth in the valleys is offset by the decrease in the total load due to less water stored. The net result is the maximum roof stress is approximately the same for any single span rise and fixed set of conditions. A fixed set of conditions, would be the same notch area, the same frequency storm, and the same locality.

**SPECIAL CONSIDERATIONS FOR STRUCTURAL SAFETY: Normal practice of roof design is based on 18kg(40 lbs.) per 929cm²(square ft.) (subject to local codes and by-laws.) Thus it is extremely important that design is in accordance with normal load factors so deflection will be slight enough in any bay to prevent progressive deflection which could cause water depths to load the roof beyond its design limits.**

## ADDITIONAL NOTCH RATINGS

The "Selecta-Drain" Chart along with Tables I and II enables the engineer to select "Control-Flo" Drains and drain pipe sizes for most Canadian applications. These calculations are computed for a proportional flow weir that is sized to give a flow of 23 L.P.M. (5 G.P.M.) per inch of head. The 23 L.P.M. (5 G.P.M.) per inch of head, notch opening, is selected as the basis of design as it offers the most economical installation as applied to actual rainfall experienced in Canada.
Should you require design criteria for locations outside of Canada, or for special project applications please contact Zurn Drainage and Control Systems Ltd., Weston, Ontario.

## LEADER AND DRAIN PIPE SIZING

Since all data in the "Selecta-Drain" Chart is based on the 50-year storm it is possible to exceed the water depth listed in these charts if a 100-year or 1000-year storm would occur. Therefore, for good design it is recommended that scuppers or other methods be used to limit water depth to the design depth and tables I and II be used to size the leaders and drain pipes. If the roof is capable of supporting more water than the design depth it is permissible to locate the scuppers or other overflow means at a height that will allow a greater water depth on the roof. However, in this case the leader and drain pipes should be sized to handle the higher flow rates possible based on a flow rate of 23 L.P.M. (5 G.P.M.) per inch of depth at the drain.

## PROPER DRAIN LOCATION

The following good design practice is recommended for selecting the proper number of "Control-Flo" drains for a given area. **On dead-level roofs,** drains should be located no further than 15.25m(50 feet) from edge of roof and no further than 30.50m(100 feet) between drains. See diagram "A" page 2. **On sloping roofs,** drains should be located in the valleys at a distance no greater than 15.25m(50 feet) from each end of the valleys and no further than 30.50m(100 feet) between drains. See diagram "B" page 2. Compliance with these recommendations will assure good run off regardless of wind direction.

# Saves Specification Time, Assures Proper Application

## QUICK, EASY SELECTION

Using the "Selecta-Drain" Chart (pages 8, 9, 10, 11) in combination with the steps and examples appearing below, should save you countless hours in engineering specification time. This vast compilation of data is related to the proper selection of drains for 34 cities. All cities in alphabetical order by Provinces. If a specific city does not appear in this tabulation, choose the city nearest your area and select the proper drain using these factors.

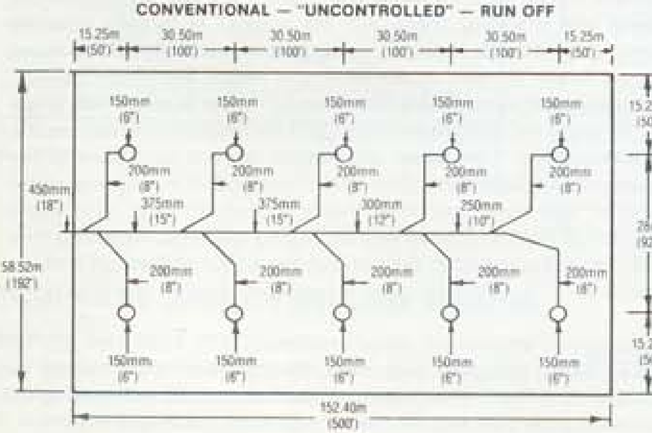
## 3 EASY STEPS ... AND 3 TYPICAL EXAMPLES FOR APPLICATION OF SURE, SCIENTIFIC CONTROL OF DRAINAGE FROM DEAD-LEVEL AND SLOPING ROOFS WITH THE ZURN CONCEPT

| TORONTO, ONTARIO | DEAD-LEVEL ROOF | 102mm(4 INCH) SLOPE | 152mm(6 INCH) SLOPE |
|---|---|---|---|
| **1** Determine total roof area or individual areas when roof is divided by expansion joints or peaks in the case of sloping roof. | Roof Area: 58.52m x 152.40m = 8918.40m² (192ft x 500ft = 96,000 sq.ft.) (See Z-105-5 layout bottom this page.) | 3 Individual Roof Areas: 19.50m x 152.40m = 2972.80m² (64ft. x 500ft. = 32,000 sq.ft.) Valleys 152.40m(500 ft.) long 3 x 2972.80 = 8918.40m² (3 x 32,000 = 96,000 sq.ft.) | 2 Individual Roof Areas: 29.87m x 152.40m = 4552m² (98 ft. x 500 ft. = 49,000 sq. ft.) Valleys 152.40m (500 ft.) long 2 x 4552 = 9104m² (2 x 49,000 = 98,000 sq.ft.) |
| **2** Divide roof area or individual areas by Zurn Notch Area Rating selected to obtain the total number of notches required. | Zurn Notch Area Rating selected for Toronto=464.50m² (5,000 sq.ft.) from "Selecta-Drain" Chart, page 11. Total Roof Area= 8918.40m² (96,000 sq.ft.) Entire roof. 464.50m² (5,000 sq.ft.) notch area = 19.2 notches - USE 20 | Zurn Notch Area Rating selected for Toronto=464.50m² (5,000 sq.ft.) from "Selecta-Drain" Chart, page 11. Total Roof Area=2972.80m² (32,000 sq.ft.) Each area. 464.50m² (5,000 sq.ft.) notch area = 6.4 notches - USE 7 PER AREA | Zurn Notch Area Rating selected for Toronto=464.50m² (5,000 sq.ft.) from "Selecta-Drain" Chart, page 11. Total Roof Area=4552m² (49,000 sq.ft.) Each area. 464.50m² (5,000 sq.ft.) notch area = 9.8 notches - USE 10 PER AREA |
| **3** Determine total number of drains required by not exceeding maximum spacing dimensions in the preceding instructions. See Diagrams "A" or "B", page 2. Divide total number of notches required to determine the number of notches per drain. Note maximum water depth at drain and use this dimension to determine scupper height. Maximum scupper height to be used is 152mm(6"). *Use this flow rate to size leaders and drain lines.* | *10 drains required. All drains must have two notches each for a total of 20 notches. Flow rate is 66 L.P.M.(14.5 G.P.M.) per notch. Size leaders for 2 notch weirs for a flow rate of 66 L.P.M. (14.5 G.P.M.) 50mm (Two inch) pipe size leaders required. Maximum water depth and scupper height is 74 mm (2.9 inches). Requires 19 hrs. draindown time max. For drain, vertical, and horizontal pipe sizing data see Tables I and II on pages 6 and 7. | **5 drains per area required located in the valleys 15.25m(50 ft.) from each end with 3 in the middle at 30.50m(100ft.) spacings. Two drains on ends with two notches—3 drains in middle one notch each for a total of 7 notches. Maximum flow rate 93 L.P.M. (20.5 G.P.M.) per notch. Leader size 50mm(2") for single notch weirs—75mm(3") notch weirs. Maximum water depth and scupper height is 104mm(4.1 inches). Requires 11 hrs. draindown time max. For drain, vertical, and horizontal pipe sizing data see Tables I and II on pages 6 and 7. | **5 drains per area required located in the valleys 15.25m(50 ft.) from each end with 3 at 30.50m(100 ft.) spacing in the middle. 10 notches are required therefore all drains must have two notches. Flow rate is 111 L.P.M. (24.5 G.P.M.) per notch. Size all leaders for 2 notch weirs. 75mm(3 inch) pipe size required. Maximum water depth and scupper height is 124mm (4.9 inches). Requires 9 hrs. draindown time max. For drain, vertical, and horizontal pipe sizing data see Tables I and II on pages 6 and 7. |

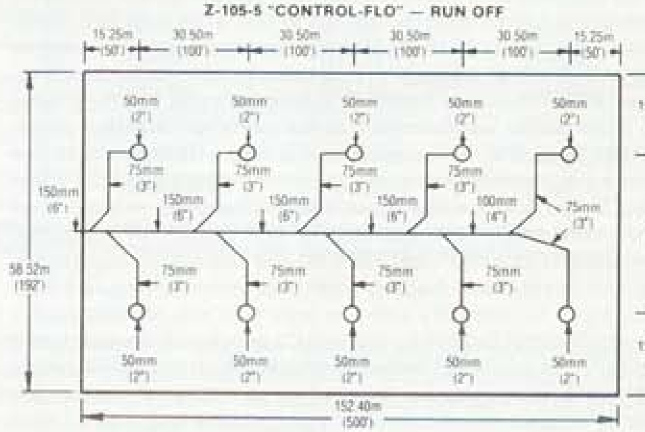
*See Diagram "A" page 2 for recommended drain placement.
**See Diagram "B" page 2 for recommended drain placement.

### DEAD LEVEL ROOF
### 6mm(1/4") PER FT. SLOPE STORM DRAIN

CONVENTIONAL — "UNCONTROLLED" — RUN OFF




Z-105-5 "CONTROL-FLO" — RUN OFF



# Saves Specification Time, Assures Proper Application

## QUICK, EASY SELECTION

Using the "Selecta-Drain" Chart (pages 8, 9, 10, 11) in combination with the steps and examples appearing below, should save you countless hours in engineering specification time. This vast compilation of data is related to the proper selection of drains for 34 cities. All cities in alphabetical order by Provinces. If a specific city does not appear in this tabulation, choose the city nearest your area and select the proper drain using these factors.

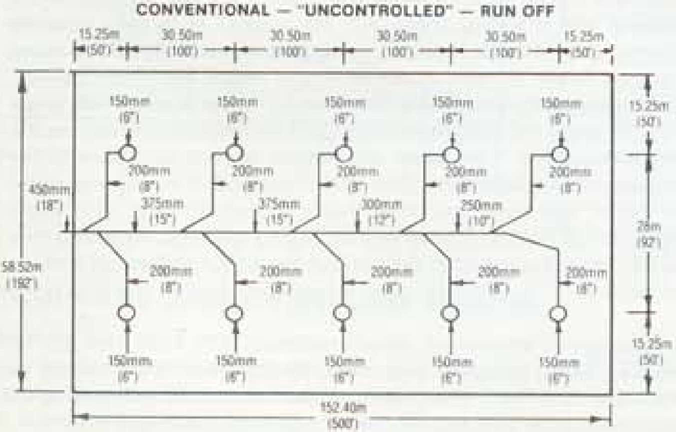
## 3 EASY STEPS ... AND 3 TYPICAL EXAMPLES FOR APPLICATION OF SURE, SCIENTIFIC CONTROL OF DRAINAGE FROM DEAD-LEVEL AND SLOPING ROOFS WITH THE ZURN CONCEPT

| TORONTO, ONTARIO | DEAD-LEVEL ROOF | 102mm(4 INCH) SLOPE | 152mm(6 INCH) SLOPE |
|---|---|---|---|
| **1** Determine total roof area or individual areas when roof is divided by expansion joints or peaks in the case of sloping roof. | Roof Area: 58.52m x 152.40m = 8918.40m² (192ft x 500ft = 96,000 sq.ft.) (See Z-105-5 layout bottom this page.) | 3 Individual Roof Areas: 19.50m x 152.40m = 2972.80m² (64ft. x 500ft. = 32,000 sq.ft.) Valleys 152.40m(500 ft.) long 3 x 2972.80 = 8918.40m² (3 x 32,000 = 96,000 sq.ft.) | 2 Individual Roof Areas: 29.87m x 152.40m = 4552m² (98 ft. x 500 ft. = 49,000 sq. ft.) Valleys 152.40m (500 ft.) long 2 x 4552 = 9104m² (2 x 49,000 = 98,000 sq.ft.) |
| **2** Divide roof area or individual areas by Zurn Notch Area Rating selected to obtain the total number of notches required. | Zurn Notch Area Rating selected for Toronto=464.50m² (5,000 sq.ft.) from "Selecta-Drain" Chart, page 11. Total Roof Area= 8918.40m² (96,000 sq.ft.) Entire roof. 464.50m² (5,000 sq.ft.) notch area = 19.2 notches - USE 20 | Zurn Notch Area Rating selected for Toronto=464.50m² (5,000 sq.ft.) from "Selecta-Drain" Chart, page 11. Total Roof Area=2972.80m² (32,000 sq.ft.) Each area. 464.50m² (5,000 sq.ft.) notch area = 6.4 notches - USE 7 PER AREA | Zurn Notch Area Rating selected for Toronto=464.50m² (5,000 sq.ft.) from "Selecta-Drain" Chart, page 11. Total Roof Area=4552m² (49,000 sq.ft.) Each area. 464.50m² (5,000 sq.ft.) notch area = 9.8 notches - USE 10 PER AREA |
| **3** Determine total number of drains required by not exceeding maximum spacing dimensions in the preceding instructions. See Diagrams "A" or "B", page 2. Divide total number of notches required to determine the number of notches per drain. Note maximum water depth at drain and use this dimension to determine scupper height. Maximum scupper height to be used is 152mm(6"). *Use this flow rate to size leaders and drain lines.* | *10 drains required. All drains must have two notches each for a total of 20 notches. Flow rate is 66 L.P.M.(14.5 G.P.M.) per notch. Size leaders for 2 notch weirs for a flow rate of 66 L.P.M. (14.5 G.P.M.) 50mm (Two inch) pipe size leaders required. Maximum water depth and scupper height is 74 mm (2.9 inches). Requires 19 hrs. draindown time max. For drain, vertical, and horizontal pipe sizing data see Tables I and II on pages 6 and 7. | **5 drains per area required located in the valleys 15.25m(50 ft.) from each end with 3 in the middle at 30.50m(100ft.) spacings. Two drains on ends with two notches—3 drains in middle one notch each for a total of 7 notches. Maximum flow rate 93 L.P.M. (20.5 G.P.M.) per notch. Leader size 50mm(2") for single notch weirs—75mm(3") notch weirs. Maximum water depth and scupper height is 104mm(4.1 inches). Requires 11 hrs. draindown time max. For drain, vertical, and horizontal pipe sizing data see Tables I and II on pages 6 and 7. | **5 drains per area required located in the valleys 15.25m(50 ft.) from each end with 3 at 30.50m(100 ft.) spacing in the middle. 10 notches are required therefore all drains must have two notches. Flow rate is 111 L.P.M. (24.5 G.P.M.) per notch. Size all leaders for 2 notch weirs. 75mm(3 inch) pipe size required. Maximum water depth and scupper height is 124mm (4.9 inches). Requires 9 hrs. draindown time max. For drain, vertical, and horizontal pipe sizing data see Tables I and II on pages 6 and 7. |

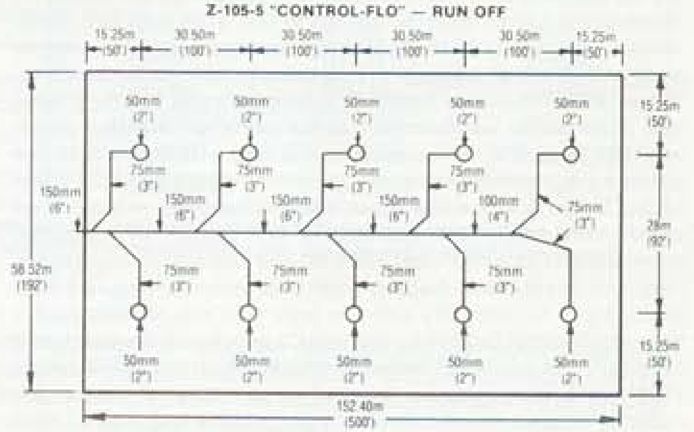
*See Diagram "A" page 2 for recommended drain placement.
**See Diagram "B" page 2 for recommended drain placement.

### DEAD LEVEL ROOF
### 6mm(1/4") PER FT. SLOPE STORM DRAIN

CONVENTIONAL — "UNCONTROLLED" — RUN OFF




Z-105-5 "CONTROL-FLO" — RUN OFF



**ZURN** # Select The Proper Vertical Drain Leaders

## ROOF DRAINAGE DATA

The flow rate for any design condition can be easily read from the data contained on the following pages; the tabulations shown below (and on the opposite page) can be used to simplify selection of drain line sizes.

**TABLE 1** —SUGGESTED RELATION OF DRAIN OUTLET AND VERTICAL LEADER SIZE TO ZURN CONTROL-FLO ROOF DRAINS (BASED ON NATIONAL PLUMBING CODE ASA-A40.8 DATA ON VERTICAL LEADERS).

| No. of Notches in Drain | Max. Flow per Notch in L.P.M. (G.P.M.) | | |
|---|---|---|---|
| | Pipe Size | | |
| | 50mm (2") | 75mm (3") | 100mm (4") |
| 1 | 136* (30*) | — | — |
| 2 | 68 (15) | 136* (30*) | — |
| 3 | 45 (10) | 136* (30*) | — |
| 4 | — | 105 (23) | 136* (30*) |
| 5 | — | 82 (18) | 136* (30*) |
| 6 | — | 68 (15) | 136* (30*) |

*Maximum flow obtainable from 1 notch with 152mm(six inch) water depth at drain.

**Table 1** should be used to select **vertical drain** leaders which at the same time establishes the drain outlet size. This table illustrates the maximum flow per notch in L.P.M. (G.P.M.) Since the Z-105-5 drain is available with a minimum of one and a maximum of six notches, calculations have already been made and are listed in this table for any quantity of weir notch openings established in your design. It was determined ten drains with two notches each weir would be required in Dead-Level Roof example on page 5. A 66 L.P.M. (14.5 G.P.M.) discharge per notch flow rate was also established.

Once this design criteria has been determined it will be the key to the proper selection of all drain outlet sizes, vertical and horizontal storm drain sizes in Table I and II. Enter the column "Number of Notches in Drain", Table I, read down the column to the figure 2 which indicates two notches in weir, then read across until you reach a figure equal to or closest figure in excess of 66 L.P.M. (14.5 G.P.M.) You will find fifteen in the column under 50mm(2") which represents the pipe size. Therefore all drain outlets and vertical leaders are 50mm(2") size.

Let us digress for a moment assuming a specific structure requires a total of six drains each containing a weir with a different number of notches. One with 1, one with 2, etc. Table 1 discloses the pipe size for one notch is 50mm(2"), two notch is 50mm(2"), three notch is 75mm(3"), four notch is 75mm(3"), five notch is 75mm(3") and six notch is 75mm(3") as they all equal or closely exceed the 66 L.P.M. (14.5 G.P.M.) design.

NOTE: Although pipe size calculations should be based on accumulated flow rate, local by-laws should be referred to for minimum pipe size requirements and roof drain spacing.

**Table II** should be used to select **horizontal** storm drain piping. Use the same flow rate 66 L.P.M. (14.5 G.P.M.) used to establish the vertical leaders to size the storm drainage system and main storm drain. Let us assume the ten drains each with two notch weirs were actually on the roof in two separate lines of five drains each and joined at a common point before leaving the building. Since Table II includes 3mm(1/8"), 6mm(¼") and 13mm(½") per foot slope, **let us use 6mm(¼") as our basis for selection** which will take us to the centre section. Starting with the first of five drains we enter the extreme left column in Table II and read down to the figure 2 since this drain has two notches in weir, read across horizontally and the size of first section of horizontal storm drain is 75mm(3") between 1st and 2nd drain, return to left hand column proceed reading down until you reach figure 4 then read across horizontally and the pipe size will be 100mm(4") between 2nd and 3rd drain, 100mm(4") between 3rd and 4th and 125mm(5") (if available) between 4th and 5th. If not available use 150mm(6"). (You may be tempted to use 100m(4") since the capacity is close. We recommend you go to the larger size.) Pipe size leaving 5th drain would be 150mm(6"). The same sizing would hold true for the second line of five drains. Since both columns of five drains each are being joined together before leaving the building there will be a total of twenty notches discharging into the main building storm sewer. Enter left hand column Table II, read down until you reach the figure twenty, then read across horizontally to the 6mm(¼") per 305mm(foot) slope column and you will see a 150mm(6") storm drain will handle the job adequately. The same procedure should be followed for sloped roof installations. The above method of sizing was done to better acquaint you with Table II and its use. The more economical and practical way of laying out and installing this same job is illustrated in the control-flo layout shown on bottom of page 5.

NOTE: Although pipe size calculations should be based on accumulated flow rates, local by-laws should be referred to for minimum pipe size requirements and roof drain spacing.

# Select Proper Horizontal Storm Drain Piping

**TABLE II** —SUGGESTED RELATION OF HORIZONTAL STORM DRAIN SIZE TO ZURN CONTROL-FLO ROOF DRAINAGE

| Total No. of Notches Discharging to Storm Drain | MAX. FLOW PER NOTCH IN L.P.M. (G.P.M.) Storm Drain Size 3mm(1/8") per 305mm(ft.) slope | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 75 (3") | 100 (4") | 125 (5") | 150 (6") | 200 (8") | 250 (10") | 300 (12") | 375 (15") |
| 1 | 136*(30*) | — | — | — | — | — | — | — |
| 2 | 77(17) | 136*(30*) | — | — | — | — | — | — |
| 3 | 50(11) | 118(26) | 136*(30*) | — | — | — | — | — |
| 4 | 36(8) | 86(19) | 136*(30*) | — | — | — | — | — |
| 5 | — | 68(15) | 127*(28*) | 136*(30*) | — | — | — | — |
| 6 | — | 59(13) | 105(23) | 136*(30*) | — | — | — | — |
| 7 | — | 50(11) | 91(20) | 136*(30*) | — | — | — | — |
| 8 | — | — | 77(17) | 127(28) | 136*(30*) | — | — | — |
| 9 | — | — | 68(15) | 114(25) | 136*(30*) | — | — | — |
| 10 | — | — | 64(14) | 100(22) | 136*(30*) | — | — | — |
| 11 | — | — | 55(12) | 91(20) | 136*(30*) | — | — | — |
| 12 | — | — | — | 82(18) | 136*(30*) | — | — | — |
| 13 | — | — | — | 77(17) | 136*(30*) | — | — | — |
| 14 | — | — | — | 73(16) | 136*(30*) | — | — | — |
| 15 | — | — | — | 68(15) | 136*(30*) | — | — | — |
| 16 | — | — | — | 64(14) | 136*(30*) | — | — | — |
| 17 | — | — | — | 59(13) | 127(28) | 136*(30*) | — | — |
| 18 | — | — | — | 55(12) | 118(26) | 136*(30*) | — | — |
| 19 | — | — | — | — | 114(25) | 136*(30*) | — | — |
| 20 | — | — | — | — | 109(24) | 136*(30*) | — | — |
| 23 | — | — | — | — | 91(20) | 136*(30*) | — | — |
| 25 | — | — | — | — | 86(19) | 136*(30*) | — | — |
| 30 | — | — | — | — | 73(16) | 127(28) | 136*(30*) | — |
| 35 | — | — | — | — | 59(13) | 109(24) | 136*(30*) | — |
| 40 | — | — | — | — | 55(12) | 95(21) | 136*(30*) | — |
| 45 | — | — | — | — | — | 86(19) | 136*(30*) | — |
| 50 | — | — | — | — | — | 77(17) | 123(27) | 136*(30*) |
| 55 | — | — | — | — | — | 68(15) | 114(25) | 136*(30*) |
| 60 | — | — | — | — | — | 64(14) | 105(23) | 136*(30*) |
| 65 | — | — | — | — | — | 59(13) | 95(21) | 136*(30*) |
| 70 | — | — | — | — | — | 55(12) | 91(20) | 136*(30*) |

| Total No. of Notches Discharging to Storm Drain | MAX. FLOW PER NOTCH IN L.P.M. (G.P.M.) Storm Drain Size 6mm(¼") per 305mm(ft.) slope | | | | | | |
|---|---|---|---|---|---|---|---|
| | 75 (3") | 100 (4") | 125 (5") | 150 (6") | 200 (8") | 250 (10") | 300 (12") |
| 1 | 136*(30*) | — | — | — | — | — | — |
| 2 | 109(24) | 136*(30*) | — | — | — | — | — |
| 3 | 73(16) | 136*(30*) | — | — | — | — | — |
| 4 | 55(12) | 127(28) | 136*(30*) | — | — | — | — |
| 5 | — | 100(22) | 136*(30*) | — | — | — | — |
| 6 | — | 82(18) | 136*(30*) | — | — | — | — |
| 7 | — | 73(16) | 127(28) | 136*(30*) | — | — | — |
| 8 | — | 64(14) | 114(25) | 136*(30*) | — | — | — |
| 9 | — | 55(12) | 100(22) | 136*(30*) | — | — | — |
| 10 | — | — | 91(20) | 136*(30*) | — | — | — |
| 11 | — | — | 82(18) | 132(29) | 136*(30*) | — | — |
| 12 | — | — | 73(16) | 118(26) | 136*(30*) | — | — |
| 13 | — | — | 68(15) | 109(24) | 136*(30*) | — | — |
| 14 | — | — | 64(14) | 100(22) | 136*(30*) | — | — |
| 15 | — | — | 59(13) | 95(21) | 136*(30*) | — | — |
| 16 | — | — | — | 91(20) | 136*(30*) | — | — |
| 17 | — | — | — | 82(18) | 136*(30*) | — | — |
| 18 | — | — | — | 77(17) | 136*(30*) | — | — |
| 19 | — | — | — | 73(16) | 136*(30*) | — | — |
| 20 | — | — | — | 68(15) | 136*(30*) | — | — |
| 23 | — | — | — | 64(14) | 132(29) | 136*(30*) | — |
| 25 | — | — | — | 59(13) | 123(27) | 136*(30*) | — |
| 30 | — | — | — | — | 100(22) | 136*(30*) | — |
| 35 | — | — | — | — | 86(19) | 136*(30*) | — |
| 40 | — | — | — | — | 77(17) | 136*(30*) | — |
| 45 | — | — | — | — | 68(15) | 123(27) | 136*(30*) |
| 50 | — | — | — | — | 59(13) | 109(24) | 136*(30*) |
| 55 | — | — | — | — | — | 100(22) | 136*(30*) |
| 60 | — | — | — | — | — | 91(20) | 136*(30*) |
| 65 | — | — | — | — | — | 82(18) | 136*(30*) |
| 70 | — | — | — | — | — | 77(17) | 127(28) |

| Total No. of Notches Discharging to Storm Drain | MAX. FLOW PER NOTCH IN L.P.M. (G.P.M.) Storm Drain Size 13mm(½") per 305mm(ft.) slope | | | | | | |
|---|---|---|---|---|---|---|---|
| | 75 (3") | 100 (4") | 125 (5") | 150 (6") | 200 (8") | 250 (10") | 300 (12") |
| 1 | 136*(30*) | — | — | — | — | — | — |
| 2 | 136*(30*) | — | — | — | — | — | — |
| 3 | 100(22) | 136*(30*) | — | — | — | — | — |
| 4 | 77(17) | 136*(30*) | — | — | — | — | — |
| 5 | 59(13) | 136*(30*) | — | — | — | — | — |
| 6 | 50(11) | 118(26) | 136*(30*) | — | — | — | — |
| 7 | — | 100(22) | 136*(30*) | — | — | — | — |
| 8 | — | 86(19) | 136*(30*) | — | — | — | — |
| 9 | — | 77(17) | 136*(30*) | — | — | — | — |
| 10 | — | 68(15) | 123(27) | 136*(30*) | — | — | — |
| 11 | — | 64(14) | 114(25) | 136*(30*) | — | — | — |
| 12 | — | 59(13) | 105(23) | 136*(30*) | — | — | — |
| 13 | — | 55(12) | 95(21) | 136*(30*) | — | — | — |
| 14 | — | — | 86(19) | 136*(30*) | — | — | — |
| 15 | — | — | 82(18) | 132(29) | 136*(30*) | — | — |
| 16 | — | — | 77(17) | 123(27) | 136*(30*) | — | — |
| 17 | — | — | 73(16) | 118(26) | 136*(30*) | — | — |
| 18 | — | — | 68(15) | 109(24) | 136*(30*) | — | — |
| 19 | — | — | 64(14) | 105(23) | 136*(30*) | — | — |
| 20 | — | — | 59(13) | 100(22) | 136*(30*) | — | — |
| 23 | — | — | 55(12) | 86(19) | 136*(30*) | — | — |
| 25 | — | — | — | 77(17) | 136*(30*) | — | — |
| 30 | — | — | — | 64(14) | 136*(30*) | — | — |
| 35 | — | — | — | 55(12) | 123(27) | 136*(30*) | |
| 40 | — | — | — | — | 105(23) | 136*(30*) | — |
| 45 | — | — | — | — | 95(21) | 136*(30*) | — |
| 50 | — | — | — | — | 86(19) | 136*(30*) | — |
| 55 | — | — | — | — | 77(17) | 136*(30*) | — |
| 60 | — | — | — | — | 68(15) | 127(28) | 136*(30*) |
| 65 | — | — | — | — | 64(14) | 118(26) | 136*(30*) |
| 70 | — | — | — | — | 59(13) | 109(24) | 136*(30*) |

*Maximum flow obtainable from 1 notch with 152mm(six inch) water depth at drain.

**TABLE III** —TO BE USED WHEN ROOF STORM WATER RUN OFF AND OTHER SURFACE WATER RUN OFF IS BEING CONSOLIDATED INTO ONE COMMON MAIN HORIZONTAL STORM SEWER.

Flow capacity of vertical leaders litres per minute (gallons per minute)

| Pipe Size | Maximum Capacity L.P.M.(G.P.M.) |
|---|---|
| 50mm(2") | 136(30) |
| 75mm(3") | 409(90) |
| 100mm(4") | 864(190) |
| †125mm(5") | 1582(348) |
| 150mm(6") | 2550(561) |

†In some areas 125mm(5") drainage pipe may not be available.

Flow capacity of horizontal storm sewers litres per minute (gallons per minute).

| Pipe Size | Slope per 305mm(Per Foot) | | |
|---|---|---|---|
| | 3mm(1/8") | 6mm(¼") | 13mm(½") |
| 75mm(3") | 163(36) | 232(51) | 327(72) |
| 100mm(4") | 355(78) | 505(111) | 714(157) |
| †125mm(5") | 646(142) | 914(201) | 1291(284) |
| 150mm(6") | 1050(231) | 1487(327) | 2100(462) |
| 200mm(8") | 2264(498) | 3205(705) | 4528(996) |
| 250mm(10") | 4100(902) | 5796(1275) | 8201(1804) |
| 300mm(12") | 6669(1467) | 9437(2076) | 13338(2934) |
| 375mm(15") | 12120(2666) | 17157(3774) | 24239(5332) |

Note: Although pipe size calculations should be based on accumulated flow rate, local by-laws should be referred to for minimum pipe size requirements and roof drain spacing.

## SCUPPERS AND OVERFLOW DRAINS

Roofing members and understructures, weakened by seepage and rot resulting from improper drainage and roof construction can give away under the weight of rapidly accumulated water during flash storms. Thus, it is recommended, and often required by building codes, to install scuppers and overflow drains in parapet-type roofs. Properly selected and sized scuppers and overflow drains are vital to a well-engineered drainage system to prevent excessive loading, erosion, seepage and rotting.

# ZURN Selecta-Drain Chart

| LOCATION | SQUARE METRE (SQUARE FOOT) NOTCH AREA RATING | ROOF LOAD FACTOR KGS (LBS.) | TOTAL ROOF SLOPE: DEAD-LEVEL | | | 51mm (2") RISE | | | 102mm (4") RISE | | | 152mm (6") RISE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L.P.M. (G.P.M.) Discharge | Draindown Time Hrs. | mm (In.) Water Depth | L.P.M. (G.P.M.) Discharge | Draindown Time Hrs. | mm (In.) Water Depth | L.P.M. (G.P.M.) Discharge | Draindown Time Hrs. | mm (In.) Water Depth | L.P.M. (G.P.M.) Discharge | Draindown Time Hrs. | mm (In.) Water Depth |
| Calgary, Alberta | 232 (2,500) | 4.7 (10.4) | 45.5 (10) | 7 | 51 (2) | 57 (12.5) | 6 | 63.5 (2.5) | 72.5 (16) | 4 | 81.5 (3.2) | 86.5 (19) | 3.2 | 96.5 (3.8) |
| | 465 (5,000) | 5.9 (13) | 57 (12.5) | 17 | 63.5 (2.5) | 66 (14.5) | 14 | 73.5 (2.9) | 82 (18) | 9 | 91.5 (3.6) | 97.5 (21.5) | 7.5 | 109 (4.3) |
| | 697 (7,500) | 6.4 (14) | 61.5 (13.5) | 28 | 68.5 (2.7) | 72.5 (16) | 22 | 81.5 (3.2) | 88.5 (19.5) | 15 | 99 (3.9) | 104.5 (23) | 12 | 117 (4.6) |
| | 929 (10,000) | 6.8 (15.1) | 66 (14.5) | 38 | 73.5 (2.9) | 77.5 (17) | 31 | 86.5 (3.4) | 93 (20.5) | 22 | 104 (4.1) | 109 (24) | 17 | 122 (4.8) |
| Edmonton, Alberta | 232 (2,500) | 4.5 (9.9) | 43 (9.5) | 7 | 48.5 (1.9) | 57 (12.5) | 6 | 63.5 (2.5) | 72.5 (16) | 4 | 81.5 (3.2) | 82 (18) | 3 | 91.5 (3.6) |
| | 465 (5,000) | 5.9 (13) | 57 (12.5) | 17 | 63.5 (2.5) | 68 (15) | 14.5 | 76 (3) | 84 (18.5) | 9.5 | 94 (3.7) | 97.5 (21.5) | 7.5 | 109 (4.3) |
| | 697 (7,500) | 6.6 (14.5) | 63.5 (14) | 28 | 71 (2.8) | 75 (16.5) | 24 | 84 (3.3) | 97.5 (21.5) | 16 | 104 (4.1) | 107 (23.5) | 12 | 119.5 (4.7) |
| | 929 (10,000) | 7.1 (15.6) | 68 (15) | 38 | 76 (3.0) | 79.5 (17.5) | 32 | 89 (3.5) | 100 (22) | 22 | 112 (4.4) | 113.5 (25) | 18 | 127 (5.0) |
| Penticton, British Columbia | 232 (2,500) | 3.8 (8.3) | 36.5 (8) | 6 | 40.5 (1.6) | 38.5 (8.5) | 4 | 43 (1.7) | 52.5 (11.5) | 3 | 58.5 (2.3) | 61.5 (13.5) | 2.3 | 68.5 (2.7) |
| | 465 (5,000) | 4.0 (8.8) | 38.5 (8.5) | 13 | 43 (1.7) | 41 (9) | 9 | 45.5 (1.8) | 57 (12.5) | 6 | 63.5 (2.5) | 68 (15) | 5 | 76 (3.0) |
| | 697 (7,500) | 4.2 (9.3) | 41 (9) | 21 | 45.5 (1.8) | 43 (9.5) | 14.5 | 48.5 (1.9) | 61.5 (13.5) | 10.5 | 68.5 (2.7) | 72.5 (16) | 8 | 81.5 (3.2) |
| | 929 (10,000) | 4.2 (9.3) | 41 (9) | 27 | 45.5 (1.8) | 45.5 (10) | 20 | 51 (2.0) | 63.5 (14) | 14 | 71 (2.8) | 75 (16.5) | 11 | 84 (3.3) |
| Vancouver, British Columbia | 232 (2,500) | 3.3 (7.3) | 32 (7) | 5.5 | 35.5 (1.4) | 38.5 (8.5) | 4 | 43 (1.7) | 47.5 (10.5) | 2.8 | 53.5 (2.1) | 57 (12.5) | 2 | 63.5 (2.5) |
| | 465 (5,000) | 4.0 (8.8) | 38.5 (8.5) | 13 | 43 (1.7) | 45.5 (10) | 10 | 51 (2) | 57 (12.5) | 6 | 63.5 (2.5) | 68 (15) | 5 | 76 (3) |
| | 697 (7,500) | 4.5 (9.9) | 43 (9.5) | 22 | 48.5 (1.9) | 50 (11) | 17 | 56 (2.2) | 63.5 (14) | 11 | 71 (2.8) | 75 (16.5) | 8.5 | 84 (3.3) |
| | 929 (10,000) | 4.9 (10.9) | 47.5 (10.5) | 30 | 53.5 (2.1) | 54.5 (12) | 24 | 61 (2.4) | 68 (15) | 15 | 76 (3) | 79.5 (17.5) | 12 | 89 (3.5) |
| Victoria, British Columbia | 232 (2,500) | 3.3 (7.3) | 32 (7) | 5.5 | 35.5 (1.4) | 38.5 (8.5) | 4 | 43 (1.7) | 43 (9.5) | 2.5 | 48.5 (1.9) | 54.5 (12) | 2 | 61 (2.4) |
| | 465 (5,000) | 4.0 (8.8) | 38.5 (8.5) | 13 | 43 (1.7) | 45.5 (10) | 10 | 51 (2) | 54.5 (12) | 6 | 61 (2.4) | 68 (15) | 5 | 76 (3) |
| | 697 (7,500) | 4.5 (9.9) | 43 (9.5) | 22 | 48.5 (1.9) | 50 (11) | 16 | 56 (2.2) | 59 (13) | 10 | 66 (2.6) | 75 (16.5) | 8 | 84 (3.3) |
| | 929 (10,000) | 4.7 (10.4) | 45.5 (10) | 30 | 51 (2) | 54.5 (12) | 23 | 61 (2.4) | 63.5 (14) | 14 | 71 (2.8) | 79.5 (17.5) | 12 | 89 (3.5) |
| Brandon, Manitoba | 232 (2,500) | 5.9 (13) | 57 (12.5) | 8 | 63.5 (2.5) | 68 (15) | 7 | 76 (3) | 82 (18) | 4.5 | 91.5 (3.6) | 95.5 (21) | 3.5 | 106.5 (4.2) |
| | 465 (5,000) | 7.3 (16.1) | 73 (16) | 20 | 81.5 (3.2) | 84 (18.5) | 17 | 94 (3.7) | 97.5 (21.5) | 11 | 109 (4.3) | 113.5 (25) | 8.5 | 127 (5) |
| | 697 (7,500) | 8.3 (18.2) | 79.5 (17.5) | 32 | 89 (3.5) | 93 (20.5) | 27 | 104 (4.1) | 107 (23.5) | 19 | 119.5 (4.7) | 125 (27.5) | 15 | 139.5 (5.5) |
| | 929 (10,000) | 9.0 (19.8) | 86.5 (19) | 43 | 96.5 (3.8) | 100 (22) | 38 | 112 (4.4) | 113.5 (25) | 26 | 127 (5.0) | 132 (29) | 21 | 147.5 (5.8) |
| Winnipeg, Manitoba | 232 (2,500) | 4.7 (10.4) | 45.5 (10) | 7 | 51 (2) | 57 (12.5) | 6 | 63.5 (2.5) | 75 (16.5) | 4 | 84 (3.3) | 86.5 (19) | 3.2 | 96.5 (3.8) |
| | 465 (5,000) | 5.9 (13) | 57 (12.5) | 17 | 63.5 (2.5) | 68 (15) | 15 | 76 (3) | 84 (18.5) | 10 | 94 (3.7) | 100 (22) | 7.5 | 112 (4.4) |
| | 697 (7,500) | 6.6 (14.5) | 63.5 (14) | 28 | 71 (2.8) | 75 (16.5) | 24 | 84 (3.3) | 93 (20.5) | 16 | 104 (4.1) | 107 (23.5) | 12 | 119.5 (4.7) |
| | 929 (10,000) | 7.1 (15.6) | 68 (15) | 39 | 76 (3) | 82 (18) | 32 | 91.5 (3.6) | 97.5 (21.5) | 22 | 109 (4.3) | 113.5 (25) | 17 | 127 (5.0) |
| Campbellton, New Brunswick | 232 (2,500) | 6.4 (14) | 62 (13.5) | 9 | 68.5 (2.7) | 70.5 (15.5) | 7 | 78.5 (3.1) | 79.5 (17.5) | 4.5 | 89 (3.5) | 91 (20) | 3.5 | 101.5 (4.0) |
| | 465 (5,000) | 9.0 (19.8) | 86.5 (19) | 22 | 96.5 (3.8) | 91 (20) | 18 | 101.5 (4) | 102.5 (22.5) | 12 | 115 (4.5) | 113.5 (25) | 9 | 127 (5.0) |
| | 697 (7,500) | 10.4 (22.9) | 100 (22) | 35 | 112 (4.4) | 102.5 (22.5) | 28 | 114.5 (4.5) | 118 (26) | 20 | 132 (5.2) | 132 (29) | 15 | 147.5 (5.8) |
| | 929 (10,000) | 11.3 (25) | 109 (24) | 47 | 122 (4.8) | 111.5 (24.5) | 40 | 124.5 (4.9) | 127.5 (28) | 29 | 142 (5.6) | 141 (31) | 22 | 157.5 (6.2) |

| LOCATION | SQUARE METRE (SQUARE FOOT) NOTCH AREA RATING | ROOF LOAD FACTOR KGS (LBS.) | TOTAL ROOF SLOPE — DEAD LEVEL: L.P.M. (G.P.M.) Discharge | DEAD LEVEL: Draindown Time Hrs. | DEAD LEVEL: mm (In.) Water Depth | 51mm (2") RISE: L.P.M. (G.P.M.) Discharge | 51mm (2") RISE: Draindown Time Hrs. | 51mm (2") RISE: mm (In.) Water Depth | 102mm (4") RISE: L.P.M. (G.P.M.) Discharge | 102mm (4") RISE: Draindown Time Hrs. | 102mm (4") RISE: mm (In.) Water Depth | 152mm (6") RISE: L.P.M. (G.P.M.) Discharge | 152mm (6") RISE: Draindown Time Hrs. | 152mm (6") RISE: mm (In.) Water Depth |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chatham, New Brunswick | 232 (2,500) | 4.5 (9.9) | 43 (9.5) | 7 | 48.5 (1.9) | 52.5 (11.5) | 5.5 | 58.5 (2.3) | 63.5 (14) | 3.5 | 71 (2.8) | 77.5 (17) | 2.9 | 86.5 (3.4) |
| | 465 (5,000) | 5.7 (12.5) | 54.5 (12) | 16 | 61 (2.4) | 63.5 (14) | 13 | 71 (2.8) | 77.5 (17) | 9 | 86.5 (3.4) | 91 (20) | 7 | 101.5 (4.0) |
| | 697 (7,500) | 6.4 (14) | 61.5 (13.5) | 27 | 68.5 (2.7) | 68 (15) | 22 | 76 (3) | 84 (18.5) | 14 | 94 (3.7) | 102.5 (22.5) | 12 | 114.5 (4.5) |
| | 929 (10,000) | 6.6 (14.6) | 63.5 (14) | 37 | 71 (2.8) | 75 (16.5) | 30 | 84 (3.3) | 91 (20) | 20 | 101.5 (4.0) | 107 (23.5) | 16 | 119.5 (4.7) |
| Moncton, New Brunswick | 232 (2,500) | 4.3 (9.4) | 41 (9) | 7 | 45.5 (1.8) | 54.5 (12) | 6 | 61 (2.4) | 63.5 (14) | 3.5 | 71 (2.8) | 72.5 (16) | 2.7 | 81.5 (3.2) |
| | 465 (5,000) | 5.9 (13) | 57 (12.5) | 17 | 63.5 (2.5) | 68 (15) | 14 | 76 (3) | 82 (18) | 9 | 91.5 (3.6) | 93 (20.5) | 7 | 104 (4.1) |
| | 697 (7,500) | 6.6 (14.6) | 63.5 (14) | 28 | 71 (2.8) | 79.5 (17.5) | 24 | 89 (3.5) | 93 (20.5) | 16 | 104 (4.1) | 104.5 (23) | 12 | 117 (4.6) |
| | 929 (10,000) | 7.5 (16.6) | 72.5 (16) | 39 | 81.5 (3.2) | 84 (18.5) | 34 | 94 (3.7) | 100 (22) | 23 | 112 (4.4) | 113.5 (25) | 17 | 127 (5.0) |
| Saint John, New Brunswick | 232 (2,500) | 5.7 (12.5) | 54.5 (12) | 8 | 61 (2.4) | 57 (12.5) | 6 | 63.5 (2.5) | 75 (16.5) | 4 | 84 (3.3) | 86.5 (19) | 3 | 96.5 (3.8) |
| | 465 (5,000) | 7.5 (16.6) | 72.5 (16) | 20 | 81.5 (3.2) | 79.5 (17.5) | 16 | 89 (3.5) | 95.5 (21) | 11 | 106.5 (4.2) | 104.5 (23) | 8 | 117 (4.6) |
| | 697 (7,500) | 8.7 (19.2) | 84 (18.5) | 32 | 94 (3.7) | 93 (20.5) | 27 | 104 (4.1) | 107 (23.5) | 19 | 119.5 (4.7) | 118 (26) | 13.5 | 132 (5.2) |
| | 929 (10,000) | 9.7 (21.3) | 93 (20.5) | 44 | 104 (4.1) | 104.5 (23) | 38 | 117 (4.6) | 113.5 (25) | 27 | 127 (5.0) | 127.5 (28) | 20 | 142 (5.6) |
| Gander, Newfoundland | 232 (2,500) | 3.5 (7.8) | 34 (7.5) | 5.5 | 38 (1.5) | 45.5 (10) | 5 | 51 (2.0) | 57 (12.5) | 3.5 | 63.5 (2.5) | 68 (15) | 2.5 | 76 (3.0) |
| | 465 (5,000) | 4.7 (10.4) | 45.5 (10) | 15 | 51 (2.0) | 57 (12.5) | 12 | 63.5 (2.5) | 72.5 (16) | 8 | 81.5 (3.2) | 82 (18) | 6.5 | 91.5 (3.6) |
| | 697 (7,500) | 5.7 (12.5) | 54.5 (12) | 25 | 61 (2.4) | 63.5 (14) | 21 | 71 (2.8) | 79.5 (17.5) | 13.5 | 89 (3.5) | 93 (20.5) | 11 | 104 (4.1) |
| | 929 (10,000) | 6.1 (13.5) | 59 (13) | 35 | 66 (2.6) | 70.5 (15.5) | 29 | 78.5 (3.1) | 84 (18.5) | 19 | 94 (3.7) | 100 (22) | 15 | 112 (4.4) |
| St. Andrews, Newfoundland | 232 (2,500) | 3.5 (7.8) | 34 (7.5) | 5.5 | 38 (1.5) | 45.5 (10) | 5 | 51 (2.0) | 59 (13) | 3.5 | 66 (2.6) | 63.5 (14) | 2.5 | 71 (2.8) |
| | 465 (5,000) | 5.2 (11.4) | 47.5 (10.5) | 15 | 53.5 (2.1) | 59 (13) | 13 | 66 (2.6) | 72.5 (16) | 8 | 81.5 (3.2) | 79.5 (17.5) | 6 | 89 (3.5) |
| | 697 (7,500) | 5.9 (13) | 57 (12.5) | 26 | 63.5 (2.5) | 66 (14.5) | 21 | 73.5 (2.9) | 82 (18) | 14 | 91.5 (3.6) | 88.5 (19.5) | 10 | 99 (3.9) |
| | 929 (10,000) | 6.6 (14.6) | 63.5 (14) | 36 | 71 (2.8) | 72.5 (16) | 30 | 81.5 (3.2) | 86.5 (19) | 20 | 96.5 (3.8) | 95.5 (21) | 14.5 | 106.5 (4.2) |
| St. John's, Newfoundland | 232 (2,500) | 5.9 (13) | 57 (12.5) | 8 | 63.5 (2.5) | 68 (15) | 7 | 76 (3.0) | 77.5 (17) | 4.5 | 86.5 (3.4) | 86.5 (19) | 3.2 | 96.5 (3.8) |
| | 465 (5,000) | 8.5 (18.7) | 82 (18) | 21 | 91.5 (3.6) | 91 (20) | 18 | 101 (4.0) | 100 (22) | 11 | 112 (4.4) | 113.5 (25) | 9 | 127 (5.0) |
| | 697 (7,500) | 10.6 (23.4) | 102.5 (22.5) | 34 | 114.5 (4.5) | 109 (24) | 29 | 122 (4.8) | 122.5 (27) | 21 | 137 (5.4) | 132 (29) | 15 | 147.5 (5.8) |
| | 929 (10,000) | 11.8 (26) | 113.5 (25) | 48 | 127 (5.0) | 129.5 (28.5) | 43 | 145 (5.7) | 143 (31.5) | 33 | 160 (6.3) | 150 (33) | 24 | 167.5 (6.6) |
| Torbay, Newfoundland | 232 (2,500) | 4.9 (10.9) | 47.5 (10.5) | 7.5 | 53.5 (2.1) | 61.5 (13.5) | 6.5 | 68.5 (2.7) | 75 (16.5) | 4 | 84 (3.3) | 84 (18.5) | 3 | 94 (3.7) |
| | 465 (5,000) | 6.4 (14) | 61.5 (13.5) | 18 | 68.5 (2.7) | 75 (16.5) | 15.5 | 84 (3.3) | 88.5 (19.5) | 10 | 99 (3.9) | 102.5 (22.5) | 8 | 114.5 (4.5) |
| | 697 (7,500) | 7.3 (16.1) | 70.5 (15.5) | 29 | 78.5 (3.1) | 84 (18.5) | 25 | 94 (3.7) | 100 (22) | 17.5 | 112 (4.4) | 113.5 (25) | 13 | 127 (5) |
| | 929 (10,000) | 8.0 (17.7) | 77.5 (17) | 40 | 86.5 (3.4) | 88.5 (19.5) | 34 | 99 (3.9) | 107 (23.5) | 24 | 119.5 (4.7) | 122.5 (27) | 19 | 137 (5.4) |
| Halifax, Nova Scotia | 232 (2,500) | 5.9 (13) | 57 (12.5) | 8 | 63.5 (2.5) | 68 (15) | 7 | 76 (3.0) | 77.5 (17) | 4.5 | 86.5 (3.4) | 86.5 (19) | 3.2 | 96.5 (3.8) |
| | 465 (5,000) | 8.5 (18.7) | 82 (18) | 21 | 91.5 (3.6) | 91 (20) | 18 | 101.5 (4.0) | 100 (22) | 11 | 112 (4.4) | 113.5 (25) | 9 | 127 (5.0) |
| | 697 (7,500) | 10.6 (23.4) | 102.5 (22.5) | 34 | 114.5 (4.5) | 109 (24) | 29 | 122 (4.8) | 122.5 (27) | 21 | 137 (5.4) | 132 (29) | 15 | 147.5 (5.8) |
| | 929 (10,000) | 11.8 (26) | 113.5 (25) | 48 | 127 (5.0) | 129.5 (28.5) | 43 | 145 (5.7) | 143 (31.5) | 33 | 160 (6.3) | 150 (33) | 24 | 167.5 (6.6) |

| LOCATION | SQUARE METRE (SQUARE FOOT) NOTCH AREA RATING | ROOF LOAD FACTOR KGS (LBS.) | TOTAL ROOF SLOPE | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | DEAD-LEVEL | | | 51mm (2") RISE | | | 102mm (4") RISE | | | 152mm (6") RISE | | |
| | | | L.P.M. (G.P.M.) Discharge | Draindown Time Hrs. | mm (In.) Water Depth | L.P.M. (G.P.M.) Discharge | Draindown Time Hrs. | mm (In.) Water Depth | L.P.M. (G.P.M.) Discharge | Draindown Time Hrs. | mm (In.) Water Depth | L.P.M. (G.P.M.) Discharge | Draindown Time Hrs. | mm (In.) Water Depth |
| Sydney, Nova Scotia | 232 (2,500) | 4.3 (9.4) | 41 (9) | 6.5 | 45.5 (1.8) | 45.5 (10) | 5 | 51 (2.0) | 57 (12.5) | 3.5 | 63.5 (2.5) | 68 (15) | 2.5 | 76 (3.0) |
| | 465 (5,000) | 5.7 (12.5) | 54.5 (12) | 16 | 61 (2.4) | 59 (13) | 13 | 66 (2.6) | 75 (16.5) | 8 | 84 (3.3) | 84 (18.5) | 6.5 | 94 (3.7) |
| | 697 (7,500) | 6.4 (14) | 61.5 (13.5) | 28 | 68.5 (2.7) | 68 (15) | 22 | 76 (3.0) | 84 (18.5) | 14 | 94 (3.7) | 97.5 (21.5) | 11 | 109 (4.3) |
| | 929 (10,000) | 7.1 (15.6) | 68 (15) | 38 | 76 (3.0) | 75 (16.5) | 30 | 84 (3.3) | 91 (20) | 20 | 101.5 (4.0) | 104.5 (23) | 16 | 117 (4.6) |
| Yarmouth, Nova Scotia | 232 (2,500) | 6.4 (14) | 61.5 (13.5) | 9 | 68.5 (2.7) | 70.5 (15.5) | 7.5 | 78.5 (3.1) | 82 (18) | 4.5 | 91.5 (3.6) | 91 (20) | 3.5 | 101.5 (4.0) |
| | 465 (5,000) | 8.3 (18.2) | 79.5 (17.5) | 21 | 89 (3.5) | 88.5 (19.5) | 18 | 99 (3.9) | 104.5 (23) | 12 | 117 (4.6) | 116 (25.5) | 9 | 129.5 (5.1) |
| | 697 (7,500) | 9.4 (20.8) | 91 (20) | 34 | 101.5 (4.0) | 102.5 (22.5) | 29 | 114.5 (4.5) | 118 (26) | 21 | 132 (5.2) | 132 (29) | 15 | 147.5 (5.8) |
| | 929 (10,000) | 10.4 (22.9) | 100 (22) | 45 | 112 (4.4) | 109 (24) | 41 | 122 (4.8) | 129.5 (28.5) | 29 | 145 (5.7) | 141 (31) | 22 | 157.5 (6.2) |
| Thunder Bay, Ontario | 232 (2,500) | 4.9 (10.9) | 47.5 (10.5) | 7.5 | 53.5 (2.1) | 61.5 (13.5) | 6.5 | 68.5 (2.7) | 75 (16.5) | 4 | 84 (3.3) | 88.5 (19.5) | 3.5 | 91.5 (3.6) |
| | 465 (5,000) | 6.1 (13.5) | 59 (13) | 18 | 66 (2.6) | 72.5 (16) | 15 | 81.5 (3.2) | 86.5 (19) | 9.5 | 96.5 (3.8) | 102.5 (22.5) | 7.5 | 114.5 (4.5) |
| | 697 (7,500) | 6.6 (14.6) | 63.5 (14) | 28 | 71 (2.8) | 77.5 (17) | 24 | 86.5 (3.4) | 93 (20.5) | 16 | 104 (4.1) | 109 (24) | 13 | 122 (4.8) |
| | 929 (10,000) | 7.1 (15.6) | 68 (15) | 38 | 76 (3.0) | 84 (18.5) | 33 | 94 (3.7) | 97.5 (21.5) | 22 | 109 (4.3) | 116 (25.5) | 18 | 129.5 (5.1) |
| Guelph, Ontario | 232 (2,500) | 5.7 (12.5) | 54.5 (12) | 8 | 61 (2.4) | 63.5 (14) | 7 | 71 (2.8) | 86.5 (19) | 5 | 96.5 (3.8) | 100 (22) | 3.7 | 112 (4.4) |
| | 465 (5,000) | 6.6 (14.6) | 63.5 (14) | 19 | 71 (2.8) | 75 (16.5) | 15.5 | 84 (3.3) | 97.5 (21.5) | 11 | 109 (4.3) | 116 (25.5) | 9 | 129.5 (5.1) |
| | 697 (7,500) | 7.3 (16.1) | 70.5 (15.5) | 29 | 78.5 (3.1) | 82 (18) | 25 | 91.5 (3.6) | 104.5 (23) | 18 | 117 (4.6) | 125 (27.5) | 14 | 139.5 (5.5) |
| | 929 (10,000) | 8.0 (17.7) | 77.5 (17) | 40 | 86.5 (3.4) | 84 (18.5) | 34 | 94 (3.7) | 109 (24) | 26 | 122 (4.8) | 132 (29) | 20 | 147.5 (5.8) |
| Hamilton, Ontario | 232 (2,500) | 5.9 (13) | 57 (12.5) | 8.5 | 63.5 (2.5) | 72.5 (16) | 7.5 | 81.5 (3.2) | 93 (20.5) | 5 | 104 (4.1) | 109 (24) | 4 | 122 (4.8) |
| | 465 (5,000) | 6.6 (14.6) | 63.5 (14) | 19 | 71 (2.8) | 79.5 (17.5) | 16 | 89 (3.5) | 104.5 (23) | 12 | 117 (4.6) | 122.5 (27) | 9 | 137 (5.4) |
| | 697 (7,500) | 6.8 (15.1) | 66 (14.5) | 28 | 73.5 (2.9) | 84 (18.5) | 26 | 94 (3.7) | 111.5 (24.5) | 20 | 124.5 (4.9) | 127.5 (28) | 15 | 142 (5.6) |
| | 929 (10,000) | 7.1 (15.6) | 68 (15) | 39 | 76 (3.0) | 86.5 (19) | 34 | 96.5 (3.8) | 116 (25.5) | 27 | 129.5 (5.1) | 134 (29.5) | 21 | 150 (5.9) |
| Kingston, Ontario | 232 (2,500) | 6.4 (14) | 61.5 (13.5) | 9 | 68.5 (2.7) | 77.5 (17) | 8 | 86.5 (3.4) | 91 (20) | 5 | 101.5 (4.0) | 109 (24) | 4 | 122 (4.8) |
| | 465 (5,000) | 7.5 (16.6) | 72.5 (16) | 20 | 81.5 (3.2) | 86.5 (19) | 18 | 96.5 (3.8) | 104.5 (23) | 12 | 117 (4.6) | 122.5 (27) | 9.5 | 137 (5.4) |
| | 697 (7,500) | 8.5 (18.7) | 82 (18) | 31 | 91.5 (3.6) | 93 (20.5) | 28 | 104 (4.1) | 111.5 (24.5) | 20 | 124.5 (4.9) | 132 (29) | 15 | 147.5 (5.8) |
| | 929 (10,000) | 8.7 (19.2) | 86.5 (19) | 42 | 96.5 (3.8) | 97.5 (21.5) | 38 | 109 (4.3) | 116 (25.5) | 27 | 129.5 (5.1) | 68 (15) | 21 | 152.5 (6.0) |
| London, Ontario | 232 (2,500) | 6.1 (13.5) | 59 (13) | 8.5 | 66 (2.6) | 72.5 (16) | 7.5 | 81.5 (3.2) | 88.5 (19.5) | 5 | 99 (3.9) | 107 (23.5) | 4 | 119.5 (4.7) |
| | 465 (5,000) | 7.1 (15.6) | 68 (15) | 20 | 76 (3.0) | 84 (18.5) | 17 | 94 (3.7) | 102.5 (22.5) | 12 | 114.5 (4.5) | 122.5 (27) | 9.5 | 137 (5.4) |
| | 697 (7,500) | 8.0 (17.7) | 77.5 (17) | 30 | 86.5 (3.4) | 88.5 (19.5) | 27 | 99 (3.9) | 109 (24) | 19 | 122 (4.8) | 129.5 (28.5) | 15 | 145 (5.7) |
| | 929 (10,000) | 8.5 (18.7) | 82 (18) | 41 | 91.5 (3.6) | 91 (20) | 36 | 101.5 (4.0) | 113.5 (25) | 27 | 127 (5.0) | 134 (29.5) | 21 | 150 (5.9) |
| North Bay, Ontario | 232 (2,500) | 5.7 (12.5) | 54.5 (12) | 8 | 61 (2.4) | 68 (15) | 7 | 76 (3.0) | 86.5 (19) | 5 | 96.5 (3.8) | 100 (22) | 3.8 | 112 (4.4) |
| | 465 (5,000) | 6.6 (14.6) | 63.5 (14) | 19 | 71 (2.8) | 79.5 (17.5) | 16 | 89 (3.5) | 97.5 (21.5) | 11 | 109 (4.3) | 113.5 (25) | 9 | 127 (5.0) |
| | 697 (7,500) | 7.5 (16.6) | 72.5 (16) | 30 | 81.5 (3.2) | 86.5 (19) | 26 | 96.5 (3.8) | 107 (23.5) | 19 | 119.5 (4.7) | 122.5 (27) | 14 | 137 (5.4) |
| | 929 (10,000) | 8.3 (18.2) | 77.5 (17) | 40 | 86.5 (3.4) | 93 (20.5) | 36 | 104 (4.1) | 111.5 (24.5) | 26 | 124.5 (4.9) | 127.5 (28) | 20 | 142 (5.6) |
| Ottawa, Ontario | 232 (2,500) | 4.7 (10.4) | 45.5 (10) | 7 | 51 (2.0) | 59 (13) | 6.5 | 66 (2.6) | 77.5 (17) | 4.5 | 86.5 (3.4) | 86.5 (19) | 3.2 | 96.5 (3.8) |
| | 465 (5,000) | 5.9 (13) | 57 (12.5) | 17 | 63.5 (2.5) | 68 (15) | 14 | 76 (3.0) | 86.5 (19) | 10 | 96.5 (3.8) | 100 (22) | 7.5 | 112 (4.4) |
| | 697 (7,500) | 6.4 (14) | 61.5 (13.5) | 27 | 68.5 (2.7) | 75 (16.5) | 23 | 84 (3.3) | 93 (20.5) | 16 | 104 (4.1) | 107 (23.5) | 12 | 119.5 (4.7) |
| | 929 (10,000) | 6.6 (14.6) | 63.5 (14) | 36 | 71 (2.8) | 79.5 (17.5) | 32 | 89 (3.5) | 97.5 (21.5) | 22 | 109 (4.3) | 113.5 (25) | 18 | 127 (5.0) |

| LOCATION | SQUARE METRE (SQUARE FOOT) NOTCH AREA RATING | ROOF LOAD FACTOR KGS (LBS.) | TOTAL ROOF SLOPE: DEAD-LEVEL L.P.M. (G.P.M.) Discharge | DEAD-LEVEL Draindown Time Hrs. | DEAD-LEVEL mm (In.) Water Depth | 51mm (2") RISE L.P.M. (G.P.M.) Discharge | 51mm (2") RISE Draindown Time Hrs. | 51mm (2") RISE mm (In.) Water Depth | 102mm (4") RISE L.P.M. (G.P.M.) Discharge | 102mm (4") RISE Draindown Time Hrs. | 102mm (4") RISE mm (In.) Water Depth | 152mm (6") RISE L.P.M. (G.P.M.) Discharge | 152mm (6") RISE Draindown Time Hrs. | 152mm (6") RISE mm (In.) Water Depth |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| St. Thomas, Ontario | 232 (2,500) | 5.7 (12.5) | 54.5 (12) | 8 | 61 (2.4) | 68 (15) | 7 | 76 (3.0) | 86.5 (19) | 5 | 96.5 (3.8) | 104.5 (23) | 4 | 117 (4.6) |
| | 465 (5,000) | 6.6 (14.6) | 63.5 (14) | 19 | 71 (2.8) | 77.5 (17) | 16 | 86.5 (3.4) | 97.5 (21.5) | 11 | 109 (4.3) | 118 (26) | 9 | 132 (5.2) |
| | 697 (7,500) | 7.1 (15.6) | 68 (15) | 29 | 76 (3.0) | 82 (18) | 26 | 91.5 (3.6) | 102.5 (22.5) | 18 | 114.5 (4.5) | 125 (27.5) | 15 | 139.5 (5.5) |
| | 929 (10,000) | 7.5 (16.6) | 72.5 (16) | 40 | 81.5 (3.2) | 86.5 (19) | 34 | 96.5 (3.8) | 107 (23.5) | 24 | 119.5 (4.7) | 132 (29) | 20 | 147.5 (5.8) |
| Timmins, Ontario | 232 (2,500) | 4.3 (9.4) | 41 (9) | 7 | 45.5 (1.8) | 57 (12.5) | 6 | 63.5 (2.5) | 72.5 (16) | 4 | 81.5 (3.2) | 86.5 (19) | 3.3 | 96.5 (3.8) |
| | 465 (5,000) | 5.7 (12.5) | 54.5 (12) | 16 | 61 (2.4) | 63.5 (14) | 14 | 71 (2.8) | 82 (18) | 9 | 91.5 (3.6) | 97.5 (21.5) | 7.5 | 109 (4.3) |
| | 697 (7,500) | 6.4 (14) | 61.5 (13.5) | 27 | 68.5 (2.7) | 70.5 (15.5) | 22 | 78.5 (3.1) | 86.5 (19) | 15 | 96.5 (3.8) | 104.5 (23) | 12 | 117 (4.6) |
| | 929 (10,000) | 6.6 (14.6) | 63.5 (14) | 36 | 71 (2.8) | 72.5 (16) | 30 | 81.5 (3.2) | 91 (20) | 21 | 101.5 (4.0) | 109 (24) | 17 | 122 (4.8) |
| Toronto, Ontario | 232 (2,500) | 5.7 (12.5) | 54.5 (12) | 8 | 61 (2.4) | 66 (14.5) | 7 | 73.5 (2.9) | 82 (18) | 4.5 | 91.5 (3.6) | 97.5 (21.5) | 3.5 | 109 (4.3) |
| | 465 (5,000) | 6.8 (15.1) | 66 (14.5) | 19 | 73.5 (2.9) | 77.5 (17) | 16 | 86.5 (3.4) | 93 (20.5) | 11 | 104 (4.1) | 111.5 (24.5) | 9 | 124.5 (4.9) |
| | 697 (7,500) | 8.0 (17.7) | 77.5 (17) | 30 | 86.5 (3.4) | 84 (18.5) | 26 | 94 (3.7) | 100 (22) | 18 | 112 (4.4) | 120.5 (26.5) | 14 | 134.5 (5.3) |
| | 929 (10,000) | 8.7 (19.2) | 82 (18) | 42 | 91.5 (3.6) | 86.5 (19) | 34 | 96.5 (3.8) | 104.5 (23) | 24 | 117 (4.6) | 127.5 (28) | 20 | 142 (5.6) |
| Windsor, Ontario | 232 (2,500) | 6.1 (13.5) | 59 (13) | 8.5 | 66 (2.6) | 70.5 (15.5) | 7.5 | 78.5 (3.1) | 84 (18.5) | 4.5 | 94 (3.7) | 107 (23.5) | 4 | 119.5 (4.7) |
| | 465 (5,000) | 7.1 (15.6) | 68 (15) | 20 | 76 (3.0) | 79.5 (17.5) | 16 | 89 (3.5) | 97.5 (21.5) | 11 | 109 (4.3) | 118 (26) | 9 | 132 (5.2) |
| | 697 (7,500) | 8.0 (17.7) | 77.5 (17) | 30 | 86.5 (3.4) | 86.5 (19) | 26 | 96.5 (3.8) | 107 (23.5) | 18 | 119.5 (4.7) | 125 (27.5) | 15 | 139.5 (5.5) |
| | 929 (10,000) | 8.7 (19.2) | 82 (18) | 42 | 91.5 (3.6) | 91 (20) | 36 | 101.5 (4.0) | 113.5 (25) | 26 | 127 (5.0) | 129.5 (28.5) | 20 | 145 (5.7) |
| Charlottetown, P.E.I. | 232 (2,500) | 4.9 (10.9) | 47.5 (10.5) | 7.5 | 53.5 (2.1) | 57 (12.5) | 6 | 63.5 (2.5) | 68 (15) | 3.8 | 76 (3.0) | 79.5 (17.5) | 3 | 89 (3.5) |
| | 465 (5,000) | 6.6 (14.6) | 63.5 (14) | 19 | 71 (2.8) | 75 (16.5) | 15.5 | 84 (3.3) | 88.5 (19.5) | 10 | 99 (3.9) | 100 (22) | 7.5 | 112 (4.4) |
| | 697 (7,500) | 7.8 (17.2) | 75 (16.5) | 31 | 84 (3.3) | 86.5 (19) | 26 | 96.5 (3.8) | 102.5 (22.5) | 18 | 114.5 (4.5) | 113.5 (25) | 13 | 127 (5.0) |
| | 929 (10,000) | 8.7 (19.2) | 84 (18.5) | 42 | 94 (3.7) | 97.5 (21.5) | 37 | 106.5 (4.2) | 111.5 (24.5) | 26 | 124.5 (4.9) | 125 (27.5) | 20 | 139.5 (5.5) |
| Montreal, Quebec | 232 (2,500) | 5.2 (11.4) | 50 (11) | 7.5 | 56 (2.2) | 61.5 (13.5) | 7 | 68.5 (2.7) | 79.5 (17.5) | 4.5 | 89 (3.5) | 97.5 (21.5) | 3.5 | 109 (4.3) |
| | 465 (5,000) | 5.9 (13) | 57 (12.5) | 17 | 63.5 (2.5) | 70.5 (15.5) | 15 | 78.5 (3.1) | 88.5 (19.5) | 10 | 99 (3.9) | 109 (24) | 8 | 122 (4.8) |
| | 697 (7,500) | 6.1 (13.5) | 59 (13) | 27 | 66 (2.6) | 72.5 (16) | 23 | 81.5 (3.2) | 93 (20.5) | 16 | 104 (4.1) | 113.5 (25) | 13 | 127 (5.0) |
| | 929 (10,000) | 6.4 (14) | 61.5 (13.5) | 36 | 68.5 (2.7) | 77.5 (17) | 31 | 86.5 (3.4) | 95.5 (21) | 22 | 106.5 (4.2) | 120.5 (26.5) | 19 | 134.5 (5.3) |
| Quebec City, Quebec | 232 (2,500) | 5.4 (12) | 52.5 (11.5) | 8 | 58.5 (2.3) | 63.5 (14) | 7 | 71 (2.8) | 79.5 (17.5) | 4.5 | 89 (3.5) | 97.5 (21.5) | 3.5 | 109 (4.3) |
| | 465 (5,000) | 6.4 (14) | 61.5 (13.5) | 18 | 68.5 (2.7) | 70.5 (15.5) | 15 | 78.5 (3.1) | 84 (18.5) | 10 | 94 (3.7) | 104.5 (23) | 8 | 117 (4.6) |
| | 697 (7,500) | 6.6 (14.6) | 63.5 (14) | 28 | 71 (2.8) | 72.5 (16) | 23 | 81.5 (3.2) | 86.5 (19) | 15 | 96.5 (3.8) | 107 (23.5) | 12 | 119.5 (4.7) |
| | 929 (10,000) | 7.1 (15.6) | 68 (15) | 37 | 76 (3.0) | 77.5 (17) | 31 | 86.5 (3.4) | 88.5 (19.5) | 20 | 99 (3.9) | 109 (24) | 17 | 122 (4.8) |
| Regina, Saskatchewan | 232 (2,500) | 4.5 (9.9) | 43 (9.5) | 7 | 48.5 (1.9) | 54.5 (12) | 6 | 61 (2.4) | 72.5 (16) | 4 | 81.5 (3.2) | 79.5 (17.5) | 3 | 89 (3.5) |
| | 465 (5,000) | 6.4 (14) | 61.5 (13.5) | 18 | 68.5 (2.7) | 68 (15) | 14 | 76 (3.0) | 86.5 (19) | 10 | 96.5 (3.8) | 97.5 (21.5) | 7.5 | 109 (4.3) |
| | 697 (7,500) | 7.3 (16.1) | 70.5 (15.5) | 29 | 78.5 (3.1) | 77.5 (17) | 24 | 86.5 (3.4) | 100 (22) | 17 | 112 (4.4) | 109 (24) | 12 | 122 (4.8) |
| | 929 (10,000) | 8.3 (18.2) | 79.5 (17.5) | 40 | 89 (3.5) | 82 (18) | 32 | 91.5 (3.6) | 104.5 (23) | 24 | 117 (4.6) | 118 (26) | 18 | 132 (5.2) |
| Saskatoon, Saskatchewan | 232 (2,500) | 4.0 (8.8) | 38.5 (8.5) | 6 | 43 (1.7) | 57 (12.5) | 6 | 63.5 (2.5) | 66 (14.5) | 3.8 | 73.5 (2.9) | 77.5 (17) | 2.8 | 86.5 (3.4) |
| | 465 (5,000) | 5.7 (12.5) | 54.5 (12) | 16 | 61 (2.4) | 68 (15) | 14.5 | 76 (3.0) | 82 (18) | 9 | 91.5 (3.6) | 95.5 (21) | 7 | 106.5 (4.2) |
| | 697 (7,500) | 6.6 (14.6) | 63.5 (14) | 28 | 71 (2.8) | 75 (16.5) | 24 | 84 (3.3) | 91 (20) | 16 | 101.5 (4.0) | 104.5 (23) | 12 | 117 (4.6) |
| | 929 (10,000) | 7.1 (15.6) | 68 (15) | 38 | 76 (3.0) | 82 (18) | 32 | 91.5 (3.6) | 97.5 (21.5) | 22 | 109 (4.3) | 113.5 (25) | 18 | 127 (5.0) |

# ZURN Control-Flo Roof Drains

## the most advanced drainage control available, lets you design roof drainage systems with confidence

## Check These ZURN Engineered Features

**Large 955cm² (148 Square-Inch) Open Area Dome** permits unobstructed flow. Dome is made of lightweight, shock-resistant aluminum and is bayonet-locked to gravel guard on weir. Aluminum Dome supplied when specified. Poly-Dome supplied standard.

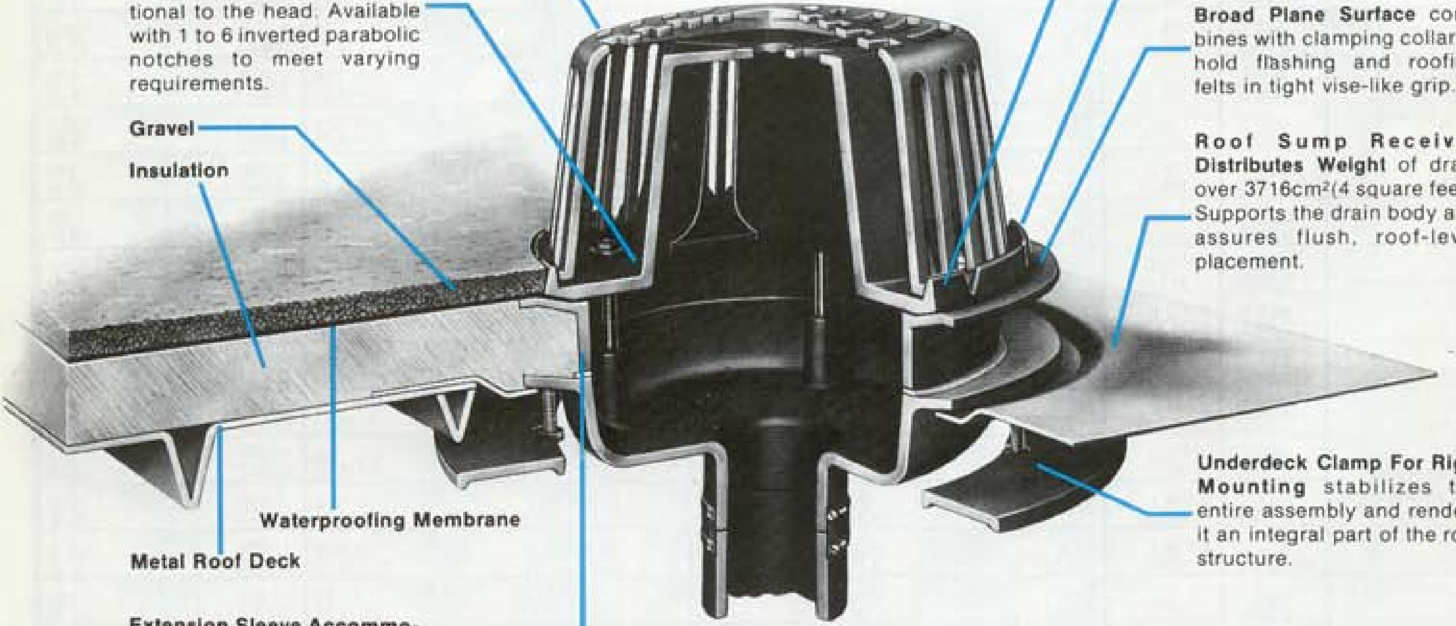
**Multi-weir Barrier** provides flow rates directly proportional to the head. Available with 1 to 6 inverted parabolic notches to meet varying requirements.

**Integral Clamping-Collar** at bottom of weir provides positive clamping action without puncturing roof or flashing. Also provides integral gravel guard.

**Bayonet-type Locking Device** on dome holds dome firmly in place with weir yet allows dome to be easily removed.

**Broad Plane Surface** combines with clamping collar to hold flashing and roofing felts in tight vise-like grip.

**Roof Sump Receiver Distributes Weight** of drain over 3716cm² (4 square feet). Supports the drain body and assures flush, roof-level placement.




**Underdeck Clamp For Rigid Mounting** stabilizes the entire assembly and renders it an integral part of the roof structure.

**Extension Sleeve Accommodates the Addition of Insulation** to a roof deck. Height as required by thickness of insulation.

Threaded, caulk, M. J. connections available. (Z-105-5-ERC w/Aluminum dome illustrated.)

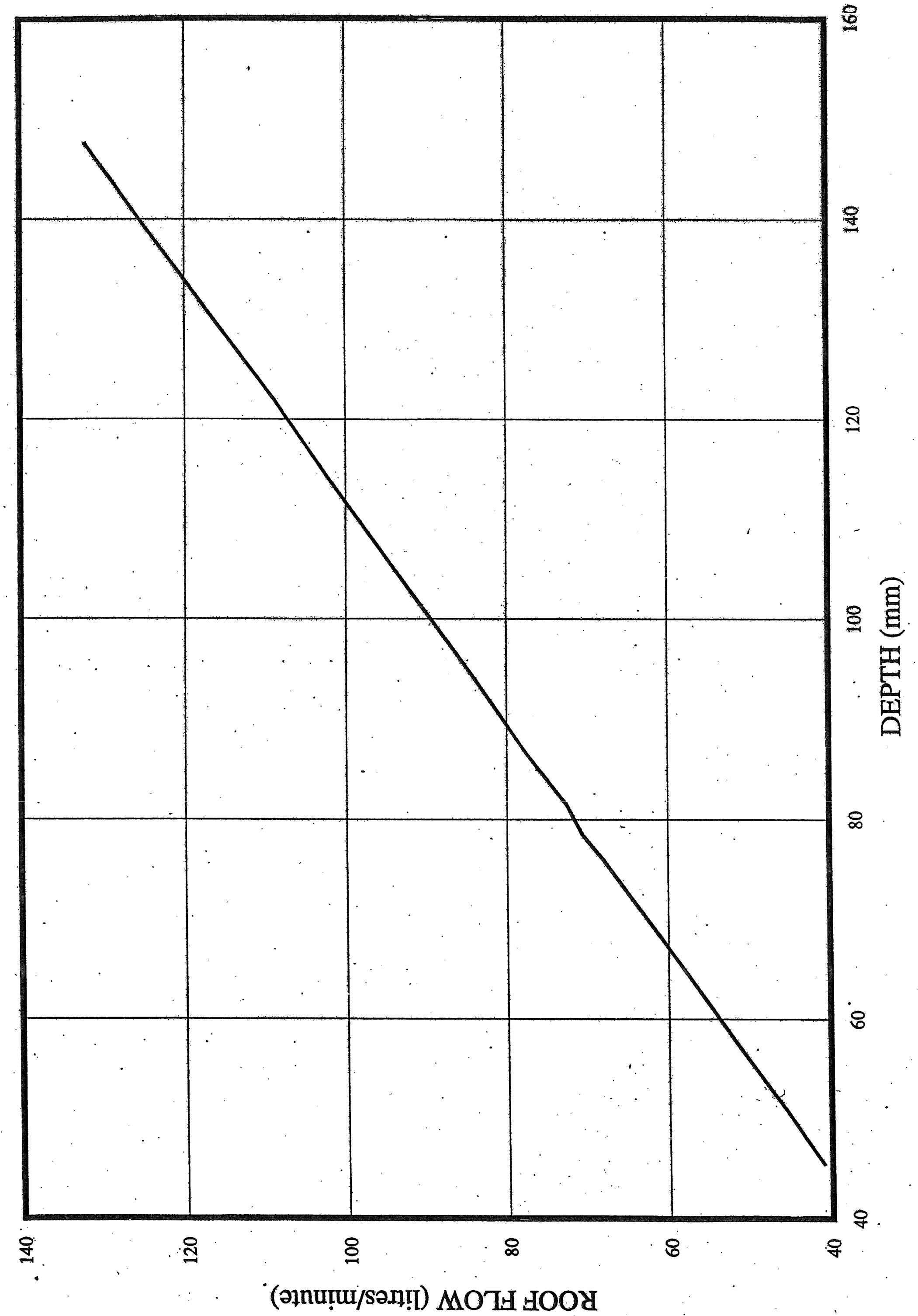

ZURN

*ZURN DRAINAGE AND CONTROL SYSTEMS LTD.*

Telephone: (416) 741-8260 Fax: (416) 741-7477

# STAGE VERSUS DISCHARGE FOR ZURN Z-105-5-ERC

"CONTROL-FLO" ROOF DRAIN




Quick Method:

For Roof Load Factor of ~~232~~ 4.7 kg & notch area rating of 232 $m^2$ (highest flow)

(Dead load) → release rate = 0.0033 L/s/$m^2$ (roof area) or 0.2 L/min/$m^2$

(i.e. 45.5 L/min / 232 $m^2$)