Alberta Guidelines for Residential Rainwater Harvesting Systems

2010

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In Alberta, the Alberta Building Code, National Plumbing Code, with select amendments, and the Canadian Electrical Code are the codes that are applicable to the design, construction and management of rainwater harvesting systems. This guidelines document and the accompanying handbook provide additional guidance for designing, constructing, and managing rainwater harvesting systems based on the minimum safety requirements established in these codes.

First Edition, July 2010

Acknowledgements

Rainwater Harvesting Task Group

The Alberta Guidelines for Residential Rainwater Harvesting Systems 2010 were developed with assistance from a Rainwater Harvesting Task Group made up of government and industry stakeholders. Task Group members represent the following stakeholder groups:

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3. Canadian Water and Wastewater Association
4. City of Calgary
5. City of Guelph
6. Ecoshift
7. Evolve Builders Group Inc.
8. GE Water & Process Technologies
9. Interpump Supply Ltd.
10. Ontario Ministry of Municipal Affairs and Housing
11. Region of Durham
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Introduction

Rainwater harvesting (RWH) is the ancient practice of collecting rainwater and storing it for later use. RWH systems are comprised of a roof catchment, conveyance network, rainwater storage tank, pump, and fixtures where rainwater is utilized. Most systems also incorporate treatment technologies to improve the quality of rainwater before and/or after storage, and include provisions for periods of insufficient rainfall (a water make-up supply) and times of excessive rainfall (overflow provisions).

The most important consideration when designing and installing a RWH system are the pertinent provincial codes and regulations, standards, and municipal bylaws. Other considerations include how the design, installation and management of RWH systems can affect the quantity of water saved and the quality of rainwater harvested, as well as cold weather suitability of the system.

The design and installation guidelines are presented in several sections, organized by the different components of RWH systems. These components are as follows:

1. Rainwater Catchment & Conveyance
2. Rainwater Storage & Tank Sizing
3. Rainwater Quality & Treatment
4. Water Make-up System & Backflow Prevention
5. Pump & Pressurized Distribution System
6. Overflow Provisions & Stormwater Management

This document is aimed at individuals with knowledge of the building sector and the basic trades involved in rainwater harvesting (i.e., plumbing, electrical, and site service work). Relevant clauses from existing codes and regulations, standards, and guidelines are presented, as well as additional design criteria derived from recent field experience and international best practices for rainwater harvesting. An accompanying document, *Alberta Guidelines for Residential Rainwater Harvesting Systems Handbook – 2010*, provides additional background, explanation and instruction for each item discussed here. Both documents are primarily focused on residential rainwater harvesting systems designed for non-potable use.

What are the Permitted Uses of Rainwater?

As of the publication date of these *Guidelines* (July 2010) applicable provincial codes and regulations in the Province of Alberta permit the use of rainwater for flushing toilets and urinals, as well as for sub-surface irrigation systems[1].

[1] Rainwater connections must be made in accordance with the Alberta Building Code. 2006. Alberta Ministry of Municipal Affairs, Edmonton, AB., and National Plumbing Code of Canada. 2005. National Research Council of Canada, Ottawa, ON.

Chapter 1. Rainwater Catchment & Conveyance

1.1 Introduction

A key component of rainwater harvesting is the collection of rainwater from a catchment surface and its conveyance to a tank for storage and future use. RWH systems most often utilize the roof of a building for collecting rainwater. While it is possible to collect rainwater from other surfaces, such as lawns, driveways or parking lots, these catchments are not addressed in this manual due to concerns surrounding the quality of rainwater collected. Once collected from the catchment surface, rainwater is transferred to the rainwater storage tank through the conveyance network. An illustration of a typical catchment and conveyance network for a residential household utilizing a below-ground rainwater storage tank is provided in Figure 1-1.

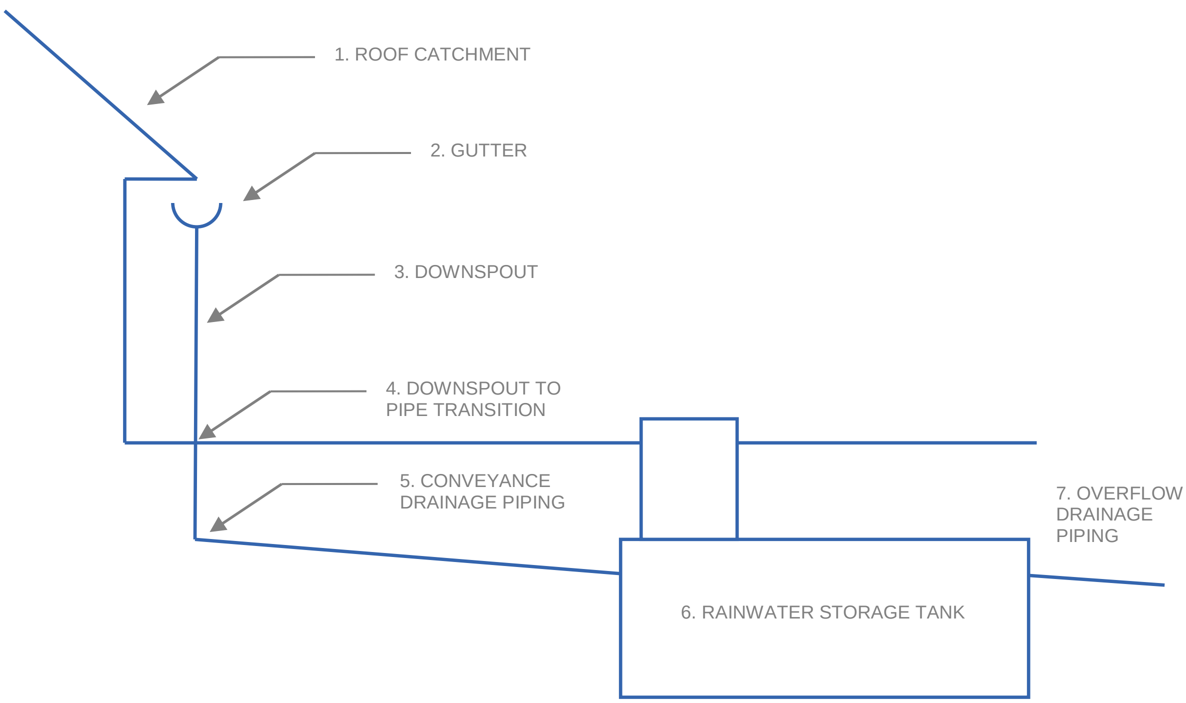

Figure 1-1. Schematic of a typical conveyance network for a below-ground rainwater storage tank

When designing and installing a conveyance network, a number of issues must be considered, including:

1. Sizing and placement of conveyance network
2. Site conditions and location/placement of storage tank
3. Cold weather issues
4. Rainwater quality

1.2 Applicable Codes, Standards, and Guidelines

Table 1-1 references codes and standards applicable to catchment and conveyance networks.

Table 1-1. Applicable standards, codes and guidelines for rainwater catchment and conveyance networks

Applicable Codes, Standards and Guidelines	Selected Provisions & Design and Installation Implications
Alberta Building Code (2006)	• **Division B , Appendix C - Table C-2. Design Data for Selected Locations** Provides rainfall values, which are used for sizing rainwater conveyance drainage pipes as per Articles 2.4.10.4. and 2.4.10.9. of the National Plumbing Code
National Plumbing Code of Canada (2005)	• **2.2.5.10. Plastic Pipe, Fittings and Solvent Cement Used Underground** • **2.2.5.12. Plastic Pipe, Fittings and Solvent Cement Used in Buildings** • **2.3.4.5. Support for Horizontal Piping** • **2.3.4.6 Support for Underground Horizontal Piping** • **2.3.5.1 Backfill of Pipe Trench** • **2.3.5.4. Protection from Frost** • **2.4.7. Cleanouts** • **2.4.10.4. Hydraulic Loads from Roofs or Paved Surfaces** • **2.4.10.9. Hydraulic Loads on Storm or Combined Building Drains or Sewers** Articles 2.2.5.10. and 2.2.5.12. specify approved pipe materials used underground and inside buildings. The NPC also provides provisions for the support and protection of piping. Subsection 2.4.7. provides provisions on the size and spacing of cleanouts, manholes, and location of cleanouts. Articles 2.4.10.4. and 2.4.10.9. specify the method for sizing conveyance drainage pipes, based upon design rainfall intensity values (15 Min Rainfall, mm) obtained from Table C-2 from the Alberta Building Code (2006), the roof catchment area, and the slope of conveyance drainage piping.
CSA Standard B128.1 (2006)	• **10 Separation** • **12.3 Buried pipe (markings)** Provides specifications for the installation of conveyance drainage piping for underground and above ground applications.
NSF Protocol P151 (1995)	Selection of roofing materials, coatings, paints, and gutters with NSF P151 certification will not impart levels of contaminants greater than those specified in the U.S. EPA's Drinking Water Regulations. Recommended where high quality rainwater is needed for the intended use.

Mandatory Documents Supplementary Documents

1.3 Design & Installation Guidelines

Design and installation guidelines:

Note: refer to *Section 1.2 Applicable Codes, Standards, and Guidelines* for the specific provisions that apply when the term "in accordance with applicable provincial codes and regulations" is used.

1. When selecting the catchment(s) for collecting rainwater:
   a. Only roof surfaces are recommended;
   b. Collection from green roofs is not recommended;
   c. Avoid sections of the roof with overhanging foliage, or trim where possible;
   d. If rainwater collected from the catchment surface must be of very high quality, materials with NSF P151 certification can be selected.
2. To maximize the volume of rainwater collected by the RWH system:
   a. The catchment surface should be as large as possible;
   b. If a roof catchment material is to be selected and installed in conjunction with the RWH system, material with minimal collection losses, such as steel, should be selected (refer to Table A-1 for details);
   c. Convey rainwater using appropriately sized and sloped components, including gutters, downspouts, and/or conveyance drainage piping; and
   d. Where possible, multiple roof catchments can be connected to a central or 'communal' rainwater storage tank.
3. Gutters and downspouts:
   a. Gutter and downspout material:
      i. Aluminum or galvanized steel are recommended,
      ii. Copper, wood, vinyl, and plastic gutter and downspout materials are not recommended,
      iii. If rainwater conveyed through gutters and downspouts must be of very high quality, materials with NSF P151 certification can be selected.
   b. Gutter slope:
      i. Where possible, slope gutters in the direction of the location of the rainwater storage tank,
      ii. Ensure a minimum slope of 0.5-2% (the greater the slope the better) is maintained throughout the gutter length.
   c. Gutter size:
      i. In general, 125 mm [5 in.] K-style gutter is commonly used and should be suitable for most typical residential roof drainage areas and gutter lengths;
      ii. To determine the size of gutter required for a given roof drainage area:
         1. Consult the applicable provincial codes and regulations pertaining to the design rainfall intensity for the site location,
         2. Calculate the area of roof draining into the gutter:

$$\boldsymbol{Roof\ Drainage\ Area}\ (\mathbf{m^2}) = Length\ (\mathrm{m}) \times Width\ (\mathrm{m})$$

Equation 1-1

Where: Length = length of the gutter served by a downspout (m)
Width = distance from the eave to the ridge of the roof drainage area served (m)

1. Refer to Table 1-2 to determine the minimum size of gutter, required based upon the roof drainage area (m^2) and design rainfall intensity values determined above:

Table 1-2. Minimum gutter sizes for given roof drainage areas and rainfall intensities[2]

Minimum Required Gutter Size and Type	Maximum Roof Drainage Area Served per Downspout (m^2)[1,2]							
	Design Rainfall Intensity (15 Min rainfall, mm):							
	18.75	25	31.25	37.5	43.75	50	56.25	62.5
100 mm [4 in.] K-style	71	53	43	35	30	27	24	21
125 mm [5 in.] K-style	130	98	78	65	56	49	43	39
150 mm [6 in.] K-style	212	159	127	106	91	79	71	64

[1]Minimum required gutter size assumes that gutters have a minimum slope (≤ 6.25%). For greater gutter slopes, the table values may be multiplied by 1.1.
[2]Maximum roof drainage area assumed roof slopes ≤ 5:12. For steeper roof pitches, multiply the table values by 0.85.

ii. For other gutter types and/or larger roof drainage areas, consult the gutter manufacturer or contractor regarding the sizing of gutter.

b. Location and spacing of downspouts:
   i. Where possible, locate downspout(s) near the location of the rainwater storage tank,
   ii. Locating downspouts at inside building corners is not recommended;
   iii. Downspouts shall serve no more than 15 m [50 ft.] of gutter length.

c. Downspout size:
   i. In general, 50x75 mm [2x3 in] rectangular-type downspouts or 75x75 mm [3x3 in.] square-type downspouts are commonly used and should be suitable for most typical residential roof drainage areas and gutter lengths,
   ii. To determine the size of downspout required:
      1. Refer to Table 1-3 to determine the minimum size of downspout (either rectangular- or square type) based upon the size of gutter the downspout is serving:

[2] Adapted from Moisture Resistant Homes: A Best Practice Guide and Plan Review Tool for Builders and Designers. 2006. U.S. Department of Housing and Urban Development, Washington, DC

Table 1-3. Minimum downspout sizes for given size of gutter[3]

Gutter Size and Type	Minimum Downspout Size (mm [in])	
	Rectangular type	Square-type
100 mm [4 in.] K-style	50x75 [2x3]	75x75 [3x3]
125 mm [5 in.] K-style	50x75 [2x3]	75x75 [3x3]
150 mm [6 in.] K-style	75 x 100 [3x4]	100x100 [4x4]

iii. For other downspout types and/or larger gutter sizes, consult the gutter/downspout manufacturer or contractor regarding the sizing of downspout.

d. Gutter and downspout installation:
   i. Gutters should be custom-fabricated and installed such that there are no seams along the length of guttering,
   ii. Gutters shall be supported by hangers (hidden hanger or spike and ferrule) that are spaced at a maximum of 450 mm [18 in.],
   iii. Downspout offsets should not exceed 3.0 m [10 ft.].

e. Refer to *Appendix A* for an example of sizing gutters and downspouts.

2. Catchment area:
   a. In cases where an entire roof catchment or other catchment surface is utilized, catchment area can be determined using:

$$\boldsymbol{Catchment\ Area}\ (\mathbf{m^2}) = Length\ (\mathrm{m}) \times Width\ (\mathrm{m})$$

Equation 1-2

Where: Length = length of the catchment surface (m)
Width = width of the catchment surface (m)

   b. In cases where sections of one roof catchment or multiple catchment surfaces are utilized, the catchment area can be determined by summing the multiple smaller areas.

3. Plan the layout of the conveyance network:
   a. For rainwater tanks located above ground:
      i. Determine the location of the tank (refer to *Chapter 2. Rainwater Storage & Tank Sizing* for guidance),
      ii. Route downspout(s) and/or conveyance drainage piping to the tank.
   b. For rainwater tanks located below ground:
      i. Determine the location of the tank (refer to *Chapter 2. Rainwater Storage & Tank Sizing* for guidance),
      ii. Plan route of conveyance drainage piping from the downspout(s) to the tank,

[3] Adapted from Moisture Resistant Homes: A Best Practice Guide and Plan Review Tool for Builders and Designers. 2006. U.S. Department of Housing and Urban Development, Washington, DC

   iii. Ensure that there are no buried service lines (gas, electricity, water, stormwater, wastewater, phone, or cable lines) in the area where digging will take place to accommodate the buried conveyance drainage pipes by contacting the municipality and service providers,
   iv. For additional guidance on planning the layout of conveyance drainage piping for below ground tanks, refer to *Appendix A.*

4. Conveyance drainage pipes:
   a. Pipe material:
      i. PVC SDR35 pipe (recommended), or ABS pipe, where
      ii. Pipe selected must be approved by applicable provincial codes and industry standards (CSA, ASTM, etc.).
   b. Pipe size and slope:
      i. Ensure a minimum slope of 0.5-2% (the greater the slope the better) is maintained throughout the pipe length,
      ii. Consult the applicable provincial codes and regulations pertaining to conveyance drainage pipe sizing, and
      iii. For estimation purposes, consult Table A-1 and Table A-4 in *Appendix A*.
   c. Cleanouts:
      i. Cleanouts are required on conveyance drainage pipes to facilitate cleaning of the conveyance drainage pipes,
      ii. Consult the applicable provincial codes and regulations pertaining to size and spacing of cleanouts, manholes and location of cleanouts.
   d. Tank connection:
      i. Rainwater conveyance drainage piping should enter the tank at a height no lower than that of the overflow drainage piping, or ideally, at a height 50 mm [2 in.] above the bottom of the overflow drainage pipe(s) entering the tank.
5. Installation of conveyance drainage pipe:
   a. Above ground pipes shall be supported in accordance with applicable provincial codes and regulations;
   b. Below ground pipes shall be located in a properly excavated space, be supported and properly backfilled in accordance with applicable provincial codes and regulations;
   c. Pipe freeze protection:
      i. Ensure that all buried pipes are located below the frost penetration depth. Consult local building authorities regarding regulations or 'rules of thumb' for frost penetration depths. For estimation purposes, refer to *Appendix A*,
      ii. Provide insulation or heat tracing for pipes buried above the frost penetration depth or exposed above grade (refer to *Appendix A* for details regarding pipe insulation).
   d. Underground non-metallic pipes should be installed with 'tracer tape' (also referred to as 'tracer wire') at a height of 300 mm [12 in.] above the pipe for the purpose of locating as-installed piping.
   e. Consult the pipe manufacturer's installation instructions regarding recommended pipe bedding, support and backfilling procedures.

6. Tank frost protection:
   a. Storage tanks located above ground at risk for freezing shall be protected by:
      i. A conveyance network bypass, where sections of downspout and/or pipe upstream of the tank shall be capable of being disconnected and/or re-routed to divert rainwater/snowmelt from entry into the tank during winter months,
      ii. A drain valve located at the bottom of the storage tank.
7. Ensure that there are no means of entry for small animals or insects into the rainwater storage tank from the conveyance network by:
   a. Properly installing all sections of the conveyance network, such that they do not have any holes or other points of entry other than those required for water flow; and
   b. Installing downspout-to-pipe transition fittings.
8. Install pre-storage treatment devices as required (refer to *Chapter 3. Rainwater Quality & Treatment* for details).

Chapter 2. Rainwater Storage & Tank Sizing

2.1 Introduction

The reservoir that is used to store rainwater harvested from roof catchments is referred to as a rainwater storage tank, a rainwater cistern, or a holding tank. Rainwater storage tanks are available in variety of different materials, such as concrete, plastic, or fiberglass, and can be installed either above- or below-ground, or alternatively, directly integrated within a building (such as built into a basement wall or foundation).

As the central hub for RWH systems, rainwater storage tanks are directly connected to a number of pipes, which must be accommodated by perforations in the tank wall. The various components of a tank and its internal components are shown in Figure 2-1.

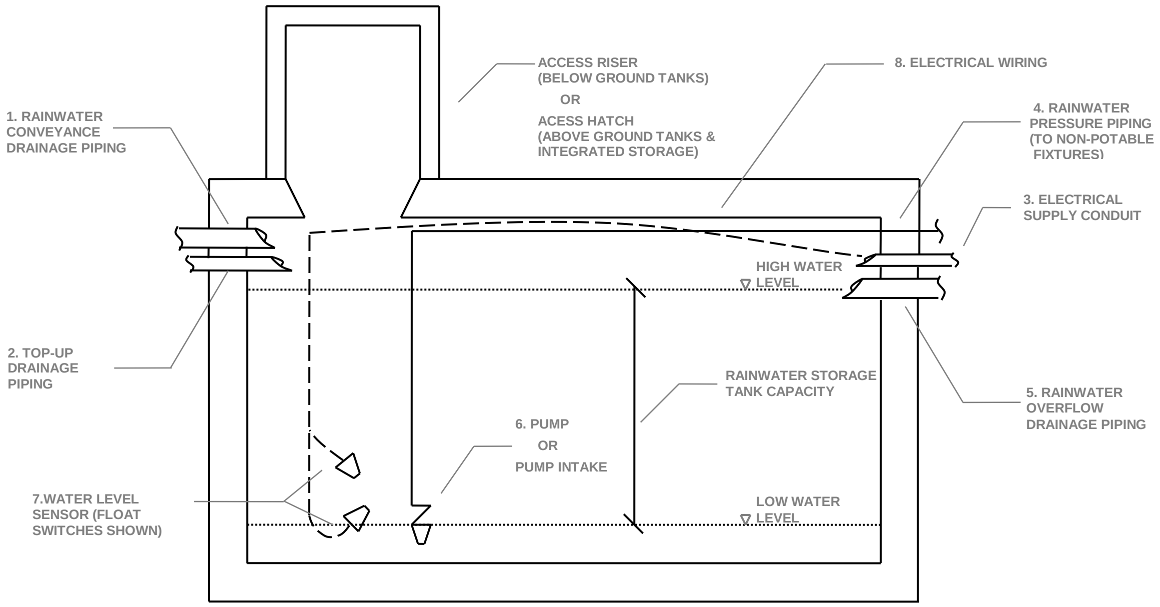

Figure 2-1. Rainwater storage tank schematic

2.2 Applicable Codes, Standards, and Guidelines

Table 2-1 references specific codes and standards that are applicable to rainwater storage tanks.

Table 2-1. Applicable standards, codes and guidelines for rainwater storage tanks

Applicable Codes, Standards, and Guidelines	Selected Provisions & Design and Installation Implications
Alberta Occupational Health & Safety Code (2009)	• **Part 5 Confined Spaces** Where entry into a rainwater tank is needed to install components, precautions outlined in Alberta OHS Code 2009 Part 5 Confined Spaces must be followed.
Alberta Private Sewage Systems Standard of Practice (2009)	• **2.5.2.7. Piping Connections to Tank** • **4.2.1.3. Infiltration/Exfiltration Prevention** • **4.2.1.4. Insulation of Tank** • **4.2.2.1. Separation Distances** • **4.2.2.3. Septic Tank Manhole Access Not Buried** • **4.2.2.4. Access Opening Lid/Cover** • **4.2.2.6. Insulation of Tank** • **4.2.2.7. Base for Septic Tank** Article 2.5.2.7. provides specifications for the connection of piping to tanks. Other aspects of septic tank design, including: minimum clearances of tanks from wells, property lines, etc., and proper installation and insulation for frost protection (Articles 4.2.1.4. and 4.2.2.6.). Other Articles pertain to access manholes and tank bedding. *Note: These specifications refer to septic tanks, but provide guidance on the design and installation requirements for rainwater storage tanks. Their use is recommended.*
CSA Standard B128.1 (2006)	• **7.0 Storage Tanks** Provides specifications for the design and installation of rainwater storage tanks, including: access openings, piping connections, overflow, drainage and venting.
NSF/ANSI Standard 61 (2008)	Selection of a plastic tank with NSF/ANSI Standard 61 certification is will not impart unsafe levels of contaminants in drinking water. Recommended where high quality rainwater is needed for the intended use.

Mandatory Documents   Supplementary Documents

2.3 Design & Installation Guidelines

Design and installation guidelines:

> **Note**: refer to *Section 2.2 Applicable Codes, Standards, and Guidelines* for the specific provisions that apply when the term "in accordance with applicable provincial codes and regulations" is used.

1. Determine the rainwater storage tank capacity:
   a. If the rainwater storage tank will be used for stormwater retention and/or as part of a stormwater management system, the tank shall be sized as required by local authorities (refer to *Chapter 6. Overflow Provisions & Stormwater Management* for details);
   b. For storage tanks used for rainwater harvesting purposes:
      i. Use the Rainwater Harvesting System Design Tool (refer to *Appendix B* for instructions on accessing the Design Tool), or
      ii. Use the method provided in the *Rainwater Storage Tank Sizing Table* section of *Appendix B.*
   c. If sizing the tank without reference to the Design Tool or Tank Sizing Table, consider:
      i. The unused volume (typically referred to as the 'dead space') when selecting tank size. If unknown, assume 20% of tank capacity will be dead space,
      ii. The collection losses from pre-storage treatment devices (refer to *Chapter 3. Rainwater Quality & Treatment* for details).
2. Determine the type of material utilized for the rainwater tank, based on:
   a. Placement (above- or below-ground, or integrated storage);
   b. Storage volume requirements;
   c. Engineering specifications (see *Section 2.2 Applicable Codes, Standards, and Guidelines* for applicable standards and consult with manufacturers for further specifications); and
   d. Connected rainwater fixtures and desired quality. (See *Section 3.2 Applicable Codes, Standards, and Guidelines* for applicable standards).
3. Determine the location of the rainwater storage tank:
   a. For all rainwater storage tank locations:
      i. Ensure the location allows for:
         1. Proper drainage of rainwater through the conveyance network (refer to *Chapter 1. Rainwater Catchment & Conveyance* for details),
         2. Proper drainage of make-up water through top-up drainage piping (refer to *Chapter 4. Make-up Water System and Backflow Prevention* for details),
         3. Proper drainage of rainwater from the storage tank to an appropriate stormwater discharge location (refer to *Chapter 6. Overflow Provisions & Stormwater Management* for details).

b. For below ground storage tanks:
    i. Identify the area(s) where the tank can be located:
        1. Ensure the location is free from buried service lines. Contact service providers to determine the location of buried service lines (gas, electricity, water, stormwater, wastewater, phone, or cable lines),
        2. Ensure the location is permitted by applicable provincial codes and regulations based upon the minimum clearance requirements for buried tanks,
        3. Ensure the location is accessible for excavation equipment and the tank delivery vehicle. Consult the excavation contractor and tank supplier for exact requirements.
    ii. Tank freeze protection:
        1. Locate the tank such that the high water level in the tank is at a depth below the frost penetration depth (consult the tank manufacturer regarding the rated burial depth of the tank),
        2. Consult applicable provincial codes and regulations and/or local building authorities to determine local frost penetration depth (refer to *Appendix A* for an estimation of frost depth),
        3. If the tank cannot be placed below frost depth, insulate with rigid Styrofoam, installed on the tank roof and extended out beyond the tank walls (refer to *Appendix A* for guidelines regarding thickness of foam insulation).

c. For above ground storage tanks:
    i. Identify the area(s) where the tank can be located:
        1. Ensure the location is permitted by applicable provincial codes and regulations and municipal zoning bylaws. Consult local building authorities for details,
        2. Ensure the location has sufficient space for access above and around the tanks for inspection and maintenance.
    ii. Tank freeze protection:
        1. If the tank is not located in a temperature-controlled environment and is at risk for freezing, winterizing or decommissioning must be performed in accordance with the guidelines below.

d. For rainwater storage tanks located within a building and/or integrated within a building:
    i. Identify the area(s) where the tank can be located:
        1. Ensure the location is permitted by applicable provincial codes and regulations and municipal zoning bylaws. Consult local building authorities for details,
        2. Ensure the location has sufficient space for the required storage volume,
        3. Ensure the location has sufficient space for access above and around the tanks for inspection and maintenance,

4. Ensure provisions (such as floor drains and/or sump pump) are in place to handle potential leaks and overflows from the storage tank,
5. Consult a structural engineer regarding the design and location of all integrated tanks, as well as indoor tanks located anywhere other than the basement or garage.

ii. Tank freezing protection:

1. Locate the tank in a temperature-controlled environment such as a heated garage or basement to prevent tank freezing,
2. If the tank is not located in a temperature-controlled environment and is at risk for freezing, winterizing or decommissioning must be performed in accordance with the guidelines below.

4. Tank frost protection:
   a. If the tank is not located in a temperature-controlled environment and is at risk for freezing, winterizing or decommissioning must be performed:

i. Winterizing:

1. Provide a heating system to maintain air temperatures above 0°C (if tank is located indoors),
2. Provide a water heating system directly inside the rainwater tank,
3. Insulate the rainwater storage tank.

ii. Decommissioning:

1. Prior to the onset of freezing temperatures, the rainwater stored in the rainwater tank must be drained,
2. Provisions shall be made to prevent the accumulation of rainwater and/or snowmelt into the tank during winter months by means of a tank bypass or tank drain valve (refer to *Section 1.3 Design & Installation Guidelines* for further details).

5. Tank access and openings [4]:
   a. Tanks shall be provided with an access opening;
   b. Access openings shall be a minimum of 450 mm [18 in.] to facilitate installation, inspection and maintenance of components within the rainwater storage tank;
   c. Access openings shall have drip-proof, non-corrosive covers;
   d. Openings that are larger than 100 mm [4 in.] shall have lockable covers;
   e. Consult applicable provincial codes and standards regarding tank access and openings.
6. Tank venting:
   a. For below ground rainwater storage tanks:

i. In general, venting of the tank through the rainwater conveyance drainage piping and overflow drainage piping connected to the tank(s) is considered to be sufficient for typical single family residential dwelling,

ii. For other dwellings, or in cases where venting by means of conveyance drainage piping and overflow drainage piping connections is considered insufficient, a vent shall be installed on each tank, where:

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[4] Adapted from CAN/CSA-B128.1-06 Design and installation of non-potable water systems. 2006. CSA International, Mississauga, ON. Refer to CSA B128.1 for further details.

1. The vent pipe shall extend from the top of tank to a minimum height of 150 mm [6 in.] above grade,
2. The vent pipe shall be of a sufficient size to permit the flow of air while the tank is filling, and shall be no less than 75 mm [3 in.] in size,
3. Vent shall terminate in a gooseneck fitting with a screen to prevent the entry of birds, rodents and insects.

b. For rainwater storage tanks located indoors and/or integrated within buildings:
   i. Rooms containing open tanks shall be vented to the outside of the building to prevent the accumulation of humidity or noxious gases.

7. Installation of storage tanks:
   a. Below ground tanks shall be placed in a properly excavated space, be supported on a tank bedding and be properly backfilled in accordance with applicable codes and standards;
   b. Integrated storage tanks must be constructed and/or installed in accordance with the designer’s instructions and good engineering practice;
   c. Consult the tank manufacturer’s installation instructions regarding recommended tank bedding, support and backfilling procedures;
   d. Connect the rainwater conveyance drainage pipe(s), overflow drainage pipe(s), rainwater pressure pipe(s) and electrical conduit(s) to the tank, ensuring that the connections are properly sealed and watertight.
8. Installation of components within the rainwater storage tank:
   a. Components installed within the tank typically include:
      i. A pump or pump intake (refer to *Chapter 5. Pump and Pressurized Distribution System* for details),
      ii. Water level sensors and/or other types of control equipment,
      iii. Electrical wiring for the pump and control equipment (refer to *Chapter 4. Make-up Water System and Backflow Prevention* for details).
   b. Entry into the rainwater storage tank, for the purposes of installing components within the tank is not recommended;
   c. If entry inside the rainwater storage tank is required, it shall be performed in accordance with Part 5 Confined Spaces of the Alberta Occupational Health & Safety Code due to the significant dangers involved when working within a confined space;
   d. To reduce and/or eliminate the need to perform work inside the storage tank:
      i. Wherever possible, install internal components using the access port, without entering the tank, or
      ii. Have RWH components installed by tank manufacturer, using personnel trained in confined spaces.
   e. Install components such that they are accessible for inspection and maintenance, without entry into tank;
   f. Components installed in the tank should be suited for a wet environment.

Chapter 3. Rainwater Quality & Treatment

3.1 Introduction

Rainwater Quality & Treatment Guidelines

There are currently no water quality guidelines that pertain specifically to the use of rainwater, either nationally or in the Province of Alberta. The *Canadian Guidelines for Domestic Reclaimed Water for Use in Toilet and Urinal Flushing* (draft, 2007) are not intended for rainwater use, but should be applied for multi-residential or commercial systems where there is the potential for direct contact. For single-family dwellings, the quality of rainwater and the need for treatment must be evaluated in the context of connected fixtures. Connected fixtures where there is minimal contact with the rainwater do not require the same quality of water as applications where users come into direct contact with the water. Treatment needs should be determined on a case by case basis by local building or health authorities, considering the recommendations of designers and preferences of end users.

Treatment Options

The quality of harvested rainwater varies greatly based on environmental and site conditions. It can be improved through simple measures in the design, installation and maintenance process, prior to the addition of any specific water treatment technology. Best practices to mitigate the impacts of environmental and site conditions on rainwater quality are provided in the Design & Installation Guidelines below.

Additional treatment can be provided if necessary through specialized technologies installed either prior to storage, or after storage and immediately prior to use. The advantages and disadvantages associated with these treatment approaches are summarized in Table 3-1.

Table 3-1. Comparison of advantages and disadvantages associated with Pre- and Post-storage treatment

Treatment Location	Advantages	Disadvantages
Pre-storage treatment	• Simple in design; operates using gravity flow (no electricity or high pressure requirements) • Prevents large particles from accumulating in the storage tank • Reduces requirements for post-storage treatment devices (or can preclude their use altogether)	• Susceptible to freezing • Requires regular cleaning and maintenance. Poorly-maintained devices may prevent rainwater from being conveyed to tank or may permit untreated rainwater to enter the tank • Multiple collection points may require a number of localized pre-treatment devices, increasing cost
Post-storage treatment	• Very high quality of water can be achieved • Located inside building, so no freezing risks • Can be used to treat more complex quality issues (i.e., pine needles in tank that create tannic acids)	• May require maintenance and replacement of filters, chemicals, or other materials • End quality depends on incoming rainwater quality and maintenance of pre-storage treatment devices • Generally more expensive than pre-storage treatment

Pre-storage treatment involves either:

1. **First-flush diversion** – where the first portion of runoff (collected from the catchment surface) is diverted away from the storage tank. One means of performing this diversion is depicted in Figure 3-1; or
2. **Settling** – where rainwater first enters a settling tank or a settling chamber of a two-compartment tank, where suspended debris can settle out before rainwater is subsequently conveyed to the rainwater storage tank (or storage chamber); or
3. **Filtration** – where leaves and other debris are captured on screens and prevented from entering the tank. Filtration can take place in gutters, on downspouts, or be integrated into the conveyance drainage pipes.

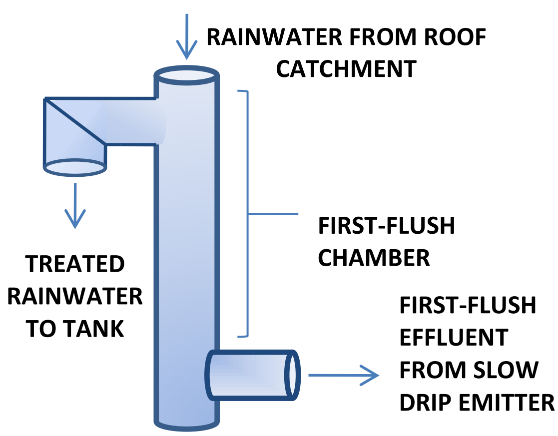

Figure 3-1. Schematic indicating the operation of a first-flush diverter

Post-storage devices include filtration, disinfection and treatment for aesthetic issues. A description of these post-storage treatment techniques, their applications and a list of available devices/options are provided in Table 3-2. A common form of post-storage treatment is 5 micron particle filtration, followed by and ultraviolet (UV) disinfection.

Table 3-2. Summary of post-storage treatment options

Treatment Method	Details	Treatment Devices/Options Available[1]
Filtration	Filtration removes suspended particles from water by passing it through a permeable material. *Water quality issues targeted:* • *Turbidity* • *Total suspended solids*	• Particle filtration (i.e., bag/sock or cartridge filter) • Slow sand filtration • Membrane filtration
Disinfection[2]	Disinfection removes or inactivates microorganisms by chemical or physical means. *Water quality issues targeted:* • *Microbiological contaminants (viruses, bacteria and protozoa)*	• Ultraviolet (UV) • Chlorine • Ozonation • Slow sand filter • Membrane filtration • Thermal treatment
Aesthetic issue treatment	Aesthetic issue treatment removes constituents from water that contribute towards colour, taste, or odour issues. *Water quality issues targeted:* • *Hydrogen sulphide* • *Organic matter* • *Manganese* • *Iron*	• Activated carbon • Ozonation • Slow sand filter • Reverse Osmosis • Membrane filtration with chemical addition

[1] Other treatment options may be available.

[2] All methods will require some level of on-line monitoring to ensure disinfection is reaching appropriate levels.

3.2 Applicable Codes, Standards, and Guidelines

Table 3-3 references specific codes and standards that are applicable to the quality of harvested rainwater and required treatment.

Table 3-3. Applicable standards, codes and guidelines for rainwater quality and treatment

Applicable Codes, Standards, and Guidelines	Selected Provisions & Design and Installation Implications
N/A	*No rainwater and/or non-potable water quality standards or treatment requirements are specified by the ABC (2006 ed.) or NPC (2005 ed.).*
Canadian Guidelines for Domestic Reclaimed Water for Use in Toilet and Urinal Flushing (Draft, 2007)	Sets out water quality guidelines, water quality testing protocols and management frameworks for domestic reclaimed water use in toilets. *Note: No quality standard has been set in Alberta for rainwater use. Any system supplying rainwater to a use that has potential direct contact and serves other than a single family dwelling should meet a quality as set out in this draft guideline.*
CSA Standard B128.1 (2006)	• **8.0 Treatment** Specifies that water supplied by a RWH system must be treated to meet the water quality standards specified by public health or other regulatory authorities.
NSF Protocol P151 (1995)	Selection of roofing materials, coatings, paints, and gutters with NSF P151 certification will not impart levels of contaminants greater than those specified in the U.S. EPA's Drinking Water Regulations. Recommended where high quality rainwater is needed for the intended use. *Note: Not legally binding unless adopted in future editions of the ABC or NPC.*
NSF/ANSI Standard 61 (2008)	Selection of a plastic tank with NSF/ANSI Standard 61 certification is will not impart unsafe levels of contaminants in drinking water. Recommended where high quality rainwater is needed for the intended use. *Note: Not legally binding unless adopted in future editions of the ABC or NPC.*

Mandatory Documents   Supplementary Documents

3.3 Design & Installation Guidelines

Design and installation guidelines:

Note: refer to *Section 3.2 Applicable Codes, Standards, and Guidelines* for the specific provisions that apply when the term "in accordance with applicable provincial codes and regulations" is used.

1. Identify factors that impact the quality of rainwater in the rainwater harvesting system, and can be mitigated through proper design and installation (see Table 3-4).

Table 3-4. Factors affecting rainwater quality and recommendations for mitigating rainwater contamination through design and installation best practices

Component of RWH System	Risk Factors	Design & Installation Best Practices
Catchment surface	1. Overhanging tree branches and animal activity 2. Leaching of chemicals and/or metals from catchment material 3. Grease and lint on catchment surface from kitchen cooktop vent and drier vent, respectively 4. Proximity to sources of air pollution (industry, major roadways, etc.)	1. Trim overhanging tree branches 2. Collect runoff from surfaces with NSF Protocol P151 certification 3. Direct drier and kitchen cooktop vents under gutters 4. Do not collect runoff from sections of catchment area at risk for poor quality
Conveyance network	1. Entry of potentially poor quality groundwater/surface water from poorly sealed joins 2. Entry of animals, rodents and/or insects from poorly sealed joints	1. Ensure underground pipe connections and fittings are secure 2. Utilize downspout-to-PVC pipe adapters
Rainwater storage tank	1. Sediment settled on bottom of tank 2. Ingress of insects, rodents or debris 3. Algae growth in tank 4. Leaching of chemicals and/or metals from tank material or components located inside tank	1. Locate pump intake a suitable distance above tank floor 2. Ensure tank hatch is properly covered and vents have screens 3. Prevent entry of direct sunlight into tank 4. Store rainwater in tank with NSF/ANSI Standard 61 certification
Overflow system	1. Backflow of storm sewage during extreme rainfall events (if overflow is connected to stormsewer)	1. Ensure overflow system is adequately designed for intense rainfall events and utilize backwater valve on overflow drainage piping

2. Determine rainwater quality and treatment requirements:
    a. In the Province of Alberta, rainwater may be used for:
        i. Toilet and urinal flushing, and
        ii. Sub-surface irrigation.
    b. Consult the applicable provincial codes and regulations to verify the fixtures for which connection to rainwater is permitted;
    c. Consult the applicable provincial codes and regulations and local authorities regarding quality and treatment requirements for the permitted rainwater fixtures;
    d. Treatment recommendations (provided for guidance purposes only):
        i. For typical single family residential dwellings consult the recommendations in Table 3-5.

Table 3-5. Treatment recommendations for typical single family residential dwellings

Rainwater Fixtures	Recommended Degree of Treatment[1]
Toilet and urinal flushing	• Treatment by pre-storage treatment device in addition to the adoption of best practices outlined in Table 3-4.
Sub-surface irrigation system	• Treatment by pre-storage treatment device in addition to the adoption of best practices outlined in Table 3-4. • Treatment by post-storage filtration device(s) as required by irrigation system manufacturer/contractor.

[1]Note: Recommendations only. Consult applicable provincial codes and regulations as well as local authorities regarding permitted fixtures, quality targets and required treatment devices.

        ii. For buildings other than a single family dwelling, the quality and treatment requirements shall be in accordance with the latest edition of the *Canadian Guidelines for Domestic Reclaimed Water for Use in Toilet and Urinal Flushing*.
3. Select and install pre-storage treatment devices:
    a. Pre-storage treatment devices must be sized to handle the peak runoff from the catchment surface (refer to *Section 1.3 Design & Installation Guidelines* for further details regarding design rainfall intensity);
    b. Filter frost protection:
        i. Locate the treatment device in a temperature-controlled environment (maintained above 0°C), or
        ii. Locate the treatment device below the frost penetration depth, or where burial below the frost penetration depth is not possible, locate the device below ground with appropriate insulation (refer to *Appendix A* for details), or
        iii. Decommission/disconnect the treatment device from the conveyance network and drain the device prior to the onset of cold weather (refer to *Section 2.3 Design & Installation Guidelines* for details).

c. First-flush diverters:
   i. Size the first-flush chamber based on the desired amount of runoff (typical diversion height is 0.5-1.5 mm) to divert from the storage tank, using the following formulas:

$$\boldsymbol{Diversion\,Volume\,(L)} = Diversion\ Height\ (mm) \times Catchment\ Area\ (m^2)$$

Equation 3-1

$$\boldsymbol{Height\ of\ First\ Flush\ Chamber\ (mm)} = \frac{4\ \times Diversion\,Volume\ (L) \times 1000}{3.14\ \times [Pipe\ Diameter\ (mm)]^2}$$

Equation 3-2

   ii. Estimate the collection losses:
      1. Initial loss factor – Equal to the Diversion height (mm),
      2. Continuous loss factor – Depends on the rate of flow through the slow drip emitter. A 5% continuous loss can be assumed, or the continuous loss can be directly measured during a rainfall event.

d. Settling tank or a settling chamber:
   i. Size the settling tank or settling chamber based on the temporary storage of a prescribed volume of runoff,
      1. Where the prescribed volume can be based on rainwater height (i.e., 5 mm of rain)[5] , as given by:

$$\boldsymbol{Settling\,Tank\,Volume\,(L)} = Rainwater\ Height\ (mm) \times Catchment\ Area\ (m^2)$$

Equation 3-3

      2. Where the prescribed volume can be based on a percentage of the capacity of the rainwater storage tank (i.e., settling chambers within two-compartment tanks typically have 1/3 the capacity of the storage chamber).

e. Pre-storage treatment filtration devices:
   i. The following components may be included as part of the filtering system:
      1. High quality gutter guards, available from gutter contractors,
      2. Leaf screens placed on the downspout, available from gutter contractors, and/or
      3. Commercially supplied rainwater filter installed in-line with conveyance drainage pipe or inside tank.
   ii. Estimate the collection losses:
      1. Initial loss factor – Reported by the supplier, or can be assumed to be negligible (0 mm),
      2. Continuous loss factor – Reported by the supplier, or can be conservatively estimated at 20%.

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[5] Adapted from Performance Evaluation of a Rainwater Harvesting System. Interim report 2008. Toronto and Region Conservation Authority, Toronto, ON.

f. Pre-storage treatment devices shall be installed in accordance with applicable provincial codes and standards and manufacturer's instructions;
g. Pre-storage treatment devices shall be installed such that they are readily accessible. Access openings to facilitate entry into the device and/or tank shall be in accordance with the guidelines in *Section 2.3 Design & Installation Guidelines*.

4. When selecting and installing post-storage treatment device(s):
    a. Pre-storage treatment device(s) should also be utilized to minimize wear on post-storage treatment devices;
    b. Post-storage treatment device(s) must be sized in accordance with the maximum flow rate of the pressure system and manufacturer's requirements;
    c. Post-storage treatment devices shall be installed in accordance with applicable provincial codes and standards and manufacturer's instructions;
    d. Post-storage treatment devices shall be installed such that they are readily accessible.

Chapter 4. Make-up Water System and Backflow Prevention

4.1 Introduction

There will occasionally be times when there is insufficient rainfall to meet the demands placed upon the rainwater harvesting system, and the storage tank will run dry. Rainwater harvesting systems need to have a system in place to recognize when there is insufficient rainwater and either trigger a warning light or switch to an alternative supply of water. This system is often referred to as a “make-up” or “back-up” system, with two general options are available:

1. **Top-up** – The rainwater storage tank can be partially filled, either manually or automatically, with make-up supplies of water from municipal (potable), or private water sources;
2. **Bypass** – The rainwater supply from the pressure system can be shut-off, either manually or automatically, and water from municipal or private sources can be directed through the rainwater pressure piping.

Of these options, only top-up systems are permitted by the National Plumbing Code 2005. The bypass method contravenes Subsection 2.7.1, of the Code which states that “a non-potable water system shall not be connected to a potable water system.”[6] As such, top-up based make-up systems are recommended.

Control Equipment

The main control equipment used to construct a make-up water system include:

1. **Solenoid valve** to open and close the potable water supply pipe,
2. **Water level sensor** (usually float switches for residential applications) to control the solenoid valve and protect against dry running the pump, and

Both float switches and solenoid valves are characterized by the terms “normally open” (N/O) and “normally closed” (N/C), described in Table 4-1.

[6] National Plumbing Code of Canada. 2005. National Research Council of Canada, Ottawa, ON.

Table 4-1. Differences between Normally Closed and Normally Open float switches and solenoid valves

Control Equipment	Normally Closed (N/C)	Normally Open (N/O)
Float switch	Permits power supply (turns things *"on"*) when the switch is in the *"down"* position (when there is a high water level in the tank)	Permits power supply (turns things *"on"*) when the switch is in the *"up"* position (when the water level is below the float switch)
Solenoid valve	When power is supplied, the valve is in an *"open"* state and permits the flow of water. Valve closes when power supply is discontinued.	When power is supplied, the valve is in a *"closed"* state and prevents the flow of water. Valve opens when power supply is discontinued.

In the down position, the float switch can initiate an automatic partial top-up of the tank from municipal water sources. The volume of make-up water needed depends on the "tether length" of the float switch, while the tether point determines the water level at which this process takes place. To maximize rainwater use, the tether length should be as short as possible and the tether point should be as low as possible, while ensuring that the water level does not drop below the pump.

While some pumps may have built in dry run protection, additional protection may be required if the built in protection is based on a timer and not water levels. A float switch can be used for dry run protection in the following configurations:

1. **Pump/float switch** – For manual top-up systems, the storage tank may run dry before additional volumes of make-up water can be supplied. A Normally Open (N/O) float switch should be wired into the pump for the purpose of dry run protection.
2. **Solenoid valve/float switch** – For automatic top-up systems, a Normally Closed (N/C) float switch should be connected to the solenoid valve supplying make-up water. If the float switch is located at a height above the pump intake, it will prevent the pump from dry running. However, if make-up supplies are insufficient, a dry run situation may still take place.
3. **Dual float switches** – For automatic top-up systems, independent float switches can be connected to both the solenoid valve supplying make-up water and the pump (N/C and N/O, respectively). The pump is protected from dry running in the event that insufficient back-up supplies are available. This method is recommended as it provides the greatest protection for the pump.

Cross-connections, Backflow Prevention and Premise Isolation

In the case of RWH systems, zone protection is required for the make-up system and premise isolation is required for the building. Numerous devices exist to provide backflow prevention. The National Plumbing Code 2005 prohibits any direct connection between a potable and non-potable system and therefore an air gap is required for zone protection of the top-up system. Following CAN/CSA-B64.10-07, premise isolation may be provided by a dual check valve, if there is no direct connection between the RWH system and the mains system. All applicable provincial codes and regulations as well as municipal bylaws must be consulted to determine what degree of backflow prevention is required (refer to *Section 4.2 Applicable Codes, Standards, and Guidelines* for details).

Figure 4-1 shows the various components of the automatic top-up system.

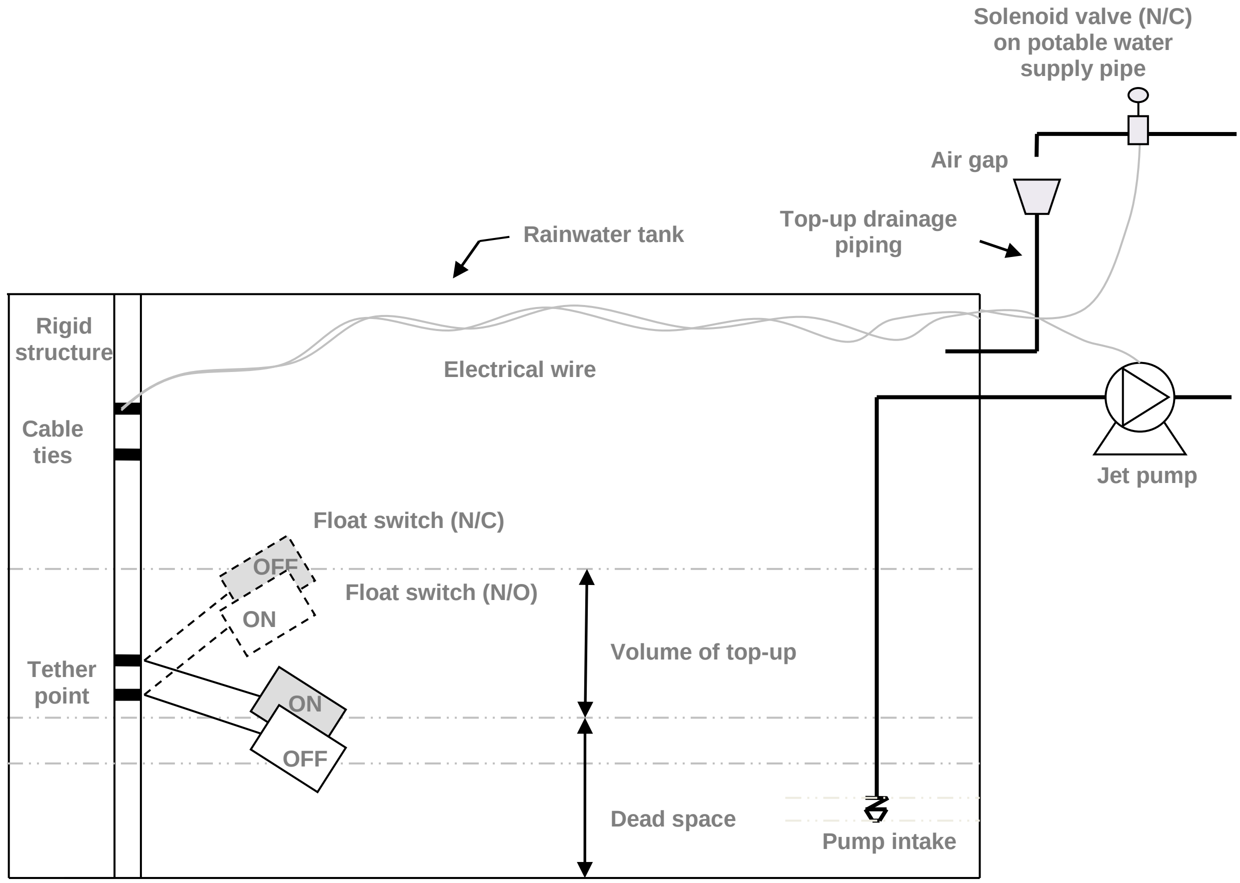

Figure 4-1. Components of an automatic top-up system

Air Gap

The typical method of backflow prevention used for top-up systems is the air gap. An air gap is one of the simplest methods of preventing backflow, and involves a physical separation between two sections of pipe that is open to the atmosphere (shown in Figure 4-1 and Figure 4-2).

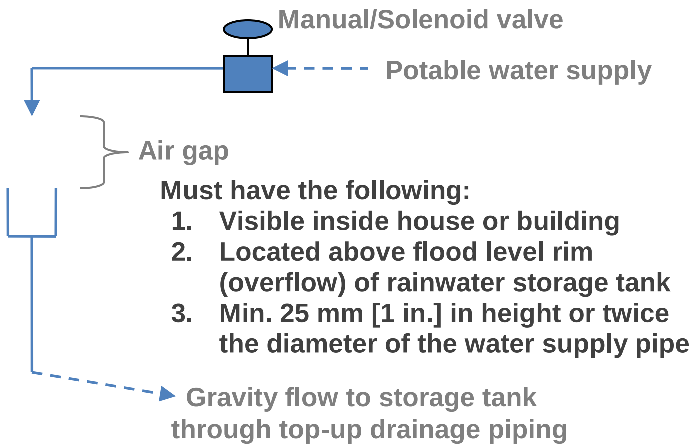

Figure 4-2. Schematic drawing of a top-up system with an air gap[7]

This physical break prevents the backflow of water since even if rainwater backed up from the tank to the gap, it would spill from the gap and not come into contact with the potable water supply. The air gap must be located higher than the overflow drainage piping from the tank and the overflow drainage piping must remain free of blockage so that excess rainwater flows to the overflow system and does not back up and overflow at the air gap.

[7] Adapted from National Plumbing Code of Canada. 2005. National Research Council of Canada, Ottawa, ON.

4.2 Applicable Codes, Standards, and Guidelines

Table 4-2 references specific codes and standards that are applicable to make-up water systems and backflow prevention.

Table 4-2. Applicable standards, codes and guidelines for make-up water systems and backflow prevention

Applicable Codes, Standards, and Guidelines	Selected Provisions & Design and Installation Implications
National Plumbing Code of Canada (2005)	• **2.2.10.15. Water Hammer Arresters** • **2.6.1.11. Thermal Expansion** • **2.6.2.1.(3) Connection of Systems** • **2.6.2.6. Premise Isolation** • **2.6.2.9. Air Gap** • **2.7.1.1. Not Permitted** Article 2.7.1.1. specifies that a RWH system (non-potable water system) shall not be connected to a potable water system. The potable water system shall be protected by means of an air gap (2.6.2.9.) for top-up systems, and requires that RWH systems be installed with backflow prevention devices as outlined by the National Plumbing Code (Sentence 2.6.2.1.(3) and Article 2.6.2.6.) and CAN/CSA-B64.10. When backflow prevention devices are installed, thermal expansion tanks must also be installed as per Article 2.6.1.11. When a solenoid valve is installed for a top-up system, a water hammer arrester may be required in accordance Article 2.2.10.15.
CAN/CSA Standard B64.10 (2001)	• **Appendix B, Table B1** • **4.3.4.2 Premise isolation** Specifies that where a potential connection exists between the RWH system (non-potable water system) and potable water system, it must be protected by means of an air gap or reduced pressure (RP) backflow prevention device. Buildings with a RWH system (rated as a severe hazard classification) must have premise isolation by means of a reduced pressure (RP) backflow preventer. *Note: CSA B64.10 permits cross connections where adequate backflow prevention is provided; however, Article 2.7.1.1. of the NPC prohibits such connections. In cases of conflict with a referenced document the NPC provision governs.*
Canadian Electrical Code (Current ed.)	• **All electrical equipment must be approved and installed to according to the requirements of the current edition Canadian Electrical Code**

Mandatory Documents   Supplementary Documents

Applicable Codes, Standards, and Guidelines	Selected Provisions & Design and Installation Implications
CSA Standard B128.1 (2006)	• **6.0 Backflow prevention** • **11.2 Cross-connection testing** Specifies that backflow prevention devices shall comply with CAN/CSA-B64.10 and the National Plumbing Code or the applicable provincial or territorial plumbing code. Section 11.2 provides guidelines for testing cross-connections after installation.
CAN/CSA Standard B64.10 (2007)	• **Appendix B, Table B1** • **5.3.4 Premise isolation** Specifies that a dual check valve (DuC) shall be used to isolate a residential premise with access to an auxiliary water supply (the RWH system), if there is no direct connection between the auxiliary water supply and the potable supply. *Note: Not legally binding. NPC (2005 ed.) references CAN/CSA B64.10 (2001 ed.). The next edition of the NPC (2010) may reference the 2007 edition of B64.10.*

Mandatory Documents   Supplementary Documents

4.3 Design & Installation Guidelines

Design and installation guidelines:

Note: refer to *Section 4.2 Applicable Codes, Standards, and Guidelines* for the specific provisions that apply when the term "in accordance with applicable provincial codes and regulations" is used.

1. Determine the type of make-up system:
    a. Automatic top-up system (recommended);
    b. Manual top-up system;
    c. No make-up system (not recommended).
2. Plan the layout of the top-up system:
    a. A top-up system is generally comprised of the following:
        i. Water level sensor(s) located in the rainwater storage tank,
        ii. A solenoid valve located on the potable water supply pipe,
        iii. An air gap,
        iv. Top-up drainage piping conveying make-up water to the rainwater storage tank, and
        v. Electrical conduit(s), containing wiring from the water level sensor(s) and pump.
    b. Determine the location of the solenoid valve and air gap in accordance with the guidelines provided below;
    c. Plan route of top-up drainage piping from the air gap to the tank (refer to Section *1.3 Design & Installation Guidelines* for guidelines and applicable provincial codes and regulations regarding drainage piping);
    d. Plan route of electrical conduit(s) from the location of the solenoid valve and power supply to the tank (refer to *Section 1.3 Design & Installation Guidelines* for piping installation guidelines);
    e. Ensure that there are no buried service lines (gas, electricity, water, stormwater, wastewater, phone, or cable lines) in the area where digging will take place to accommodate the buried top-up drainage piping and/or electrical conduit by contacting the municipality and service providers.
3. Water level sensors:
    a. Select the appropriate water level sensor(s) for the RWH system (float switch, ultrasonic level sensor, or other);
    b. Float switches:
        i. Select the type of float switch:
            1. Solenoid valve actuation is typically provided by a N/C float switch, for top-up systems,
            2. Pump dry run protection is typically provided by a N/O float switch.
        ii. Electrical requirements:
            1. The voltage rating of the float switch must match that of the device it controls (120 V or 240 V),
            2. The power rating (Watts [W] or Horsepower [HP]) of the float switch must be sufficient to carry the total load of the device it

controls, or alternatively, float switches may be low voltage and used to activate the pump through relays in a control panel,

3. Spliced electrical wiring must be water tight and be of sufficient electrical rating as determined by the loads handled by the float switch and the total length of wiring,
4. All electrical connections for float switches must be made by a licensed electrician in accordance with the manufacturer's instructions.

c. Float switch installation:
   i. The float switch shall be tethered to a rigid freestanding object, such as a vertical section of pipe or the pump, that:
      1. Permits the float switch to rise and fall without any obstructions,
      2. Is located in area where it is easily accessible and can be withdrawn from the tank without requiring entry into the tank.
   ii. To set the operating parameters of the float switch:
      1. To maximize rainwater collection, the tether length should be as short as possible: 75 mm [3 in.]. Refer to the manufacturer's installation instructions for details,
      2. To maximize rainwater collection, the tether point should be as low as possible (such that the float is 50 mm [2 in.] above the pump intake when in the down position),
      3. If utilizing a dual float switch configuration, the float switch controlling the solenoid valve should be located a minimum of 75 mm [3 in.] above the float switch controlling the pump.

d. Other water level sensors shall be selected and installed in accordance with applicable provincial codes and regulations, where all electrical connections must be made by a licensed electrician in accordance with the manufacturer's instructions.

4. Solenoid valves and shut-off valves:
   a. Select the type and size of solenoid valve and/or shut-off valve:
      i. All valves must be suitable for potable water and pressure applications,
      ii. Valve openings must be no less than the size of the piping where they are located,
      iii. Top-up systems typically use a N/C solenoid valve,
      iv. Solenoid valves with a 'slow close' or 'soft close' are recommended.
   b. Electrical requirements:
      i. Solenoid valves must be wired into a power supply in conjunction with a water level sensor;
   c. Solenoid valve and shut-off valve installation:
      i. Solenoid valves or shut-off valves used as part of a top-up system shall be installed on the potable water supply pipe upstream of the air gap,
      ii. Solenoid valves must be installed by a licensed plumber and electrician in accordance with the manufacturer's installation instructions.
   d. Water hammer protection:
      i. If a 'slow close' or 'soft close' solenoid valve is not utilized a water hammer arrester shall be installed on the potable water supply piping

upstream of the solenoid valve in accordance with applicable provincial codes and regulations.

5. Air gap:
    a. An air gap is required as part of a top-up system for the purpose backflow prevention (zone protection);
    b. Air gaps shall be designed and installed in accordance with applicable provincial codes and regulations. For guidance purposes only, the following guidelines are provided:
        i. The gap must be unobstructed – mechanical supports fixing the potable water supply pipe to the top-up drainage pipe, or other components located at or between the potable water supply pipe and top-up drainage pipe is not permitted,
        ii. The air gap must be located in an area where it can be observed and inspected,
        iii. The air gap must be installed at a height above the flood level rim (overflow) of the rainwater storage tank. If not, there is a risk that rainwater will back up the top-up drainage pipe and overflow from the air gap,
        iv. The air gap height must be at least 25 mm [1 in.] or twice the diameter of the water supply pipe.
    c. Splash and water damage prevention:
        i. To prevent make-up water from splashing at the air gap, install the following:
            1. Flow restrictor, installed upstream of the solenoid valve, and/or
            2. Aerator, installed where the potable water supply pipe terminates, and/or
            3. Extended length of vertical pipe with the end of the pipe cut at a angle no less than 45° (to produce laminar flow), installed where the potable water supply pipe terminates above the air gap.
        ii. To prevent water damage to rooms where the air gap is located:
            1. Locate air gaps near a floor drain,
            2. Install an overflow on the top-up drainage pipe, located downstream of the air gap to direct excess make-up water to the sanitary sewer (where permitted by local authorities),
            3. Appropriately size and slope the top-up drainage piping.
    d. Make-up water flow rate:
        i. To ensure RWH system operation during top-up, the following measures are recommended:
            1. The flow rate of make-up water should be equivalent to that of the maximum flow rate of the rainwater supply pump, or
            2. The water level sensor(s) shall be configured to provide a sufficient reserve volume in the rainwater storage tank (i.e., where said reserve volume shall be equivalent to that of the average daily rainwater demand for the RWH system).

6. Top-up drainage pipes:
    a. Pipe material:
        i. ABS pipe (recommended), where
        ii. Pipe selected must be approved by the applicable provincial codes and regulations, and industry standards (CSA, ASTM, etc.).
    b. Pipe size and slope:
        i. Top-up drainage piping shall be sized to handle the maximum flow rate of make-up water discharged at the air gap,
        ii. For a typical single family residential dwelling (provided for guidance purposes only):
            1. Top-up drainage piping shall be no less than 50 mm [2 in.] in size when served by a potable water supply pipe no more than 18 mm [3/4 in.] in size.
        iii. Ensure a minimum slope of 0.5-2% (the greater the slope the better) is maintained throughout the pipe length.
    c. Consult the applicable provincial codes and regulations pertaining to the installation of drainage piping (refer to *Section 1.2 Applicable Codes, Standards, and Guidelines* for details).
7. Premise isolation:
    a. Backflow preventers must be installed for the purpose of premise isolation. The following guidelines are based on CAN/CSA-B64.10-07; however, this edition is not yet adopted in the Alberta Building Code 2006 or National Plumbing Code 2005 (refer to *Section 4.2 Applicable Codes, Standards, and Guidelines* for further details);
    b. Backflow preventer selection:
        i. Residential premises with access to an auxiliary water supply (not directly connected) must be isolated from the potable water supply by a dual check valve (DuC) backflow preventer,
        ii. All other premises with access to an auxilriary water supply (including residential premises with a direct connection) must be isolated from the potable water supply by a reduced pressure (RP) backflow preventer. A double check valve assembly (DCVA) may be permitted, consult municipal bylaws and local building officials.
    c. Protection against thermal expansion:
        i. If a backflow preventer is installed for premise isolation, the building potable water supply piping must be protected from thermal expansion by installation of an appropriately sized diaphragm expansion tank, selected and installed in accordance with applicable provincial codes and regulations.
    d. Backflow preventer testing and maintenance:
        i. Backflow preventers shall be tested and maintained in accordance with CAN/CSA-B64.10.1-07 Maintenance and Field Testing of Backflow Preventers.

8. Electrical wiring:
    a. All electrical wiring must be installed in accordance with the applicable provincial codes and regulations, including the current edition of the Canadian Electrical Code.
9. Electrical conduit and rainwater service conduit:
    a. Wiring located underground shall be provided with mechanical protection by means of an electrical conduit, or other approved means;
    b. To facilitate repair and/or replacement of underground rainwater pressure piping, piping should be installed inside a rainwater service conduit, where the conduit material can be flexible drainage tubing (typically referred to as “Big ‘O’ ” tubing) or other suitable material.

Chapter 5. Pump and Pressurized Distribution System

5.1 Introduction

To supply rainwater to permitted fixtures a pressurized distribution system is often required, including a pump, pressure tank, pressure switch, and associated plumbing and electrical components, as shown in Figure 5-1. In general, the system should be designed the same as for a potable water system that uses a private well or potable water cistern, for example.

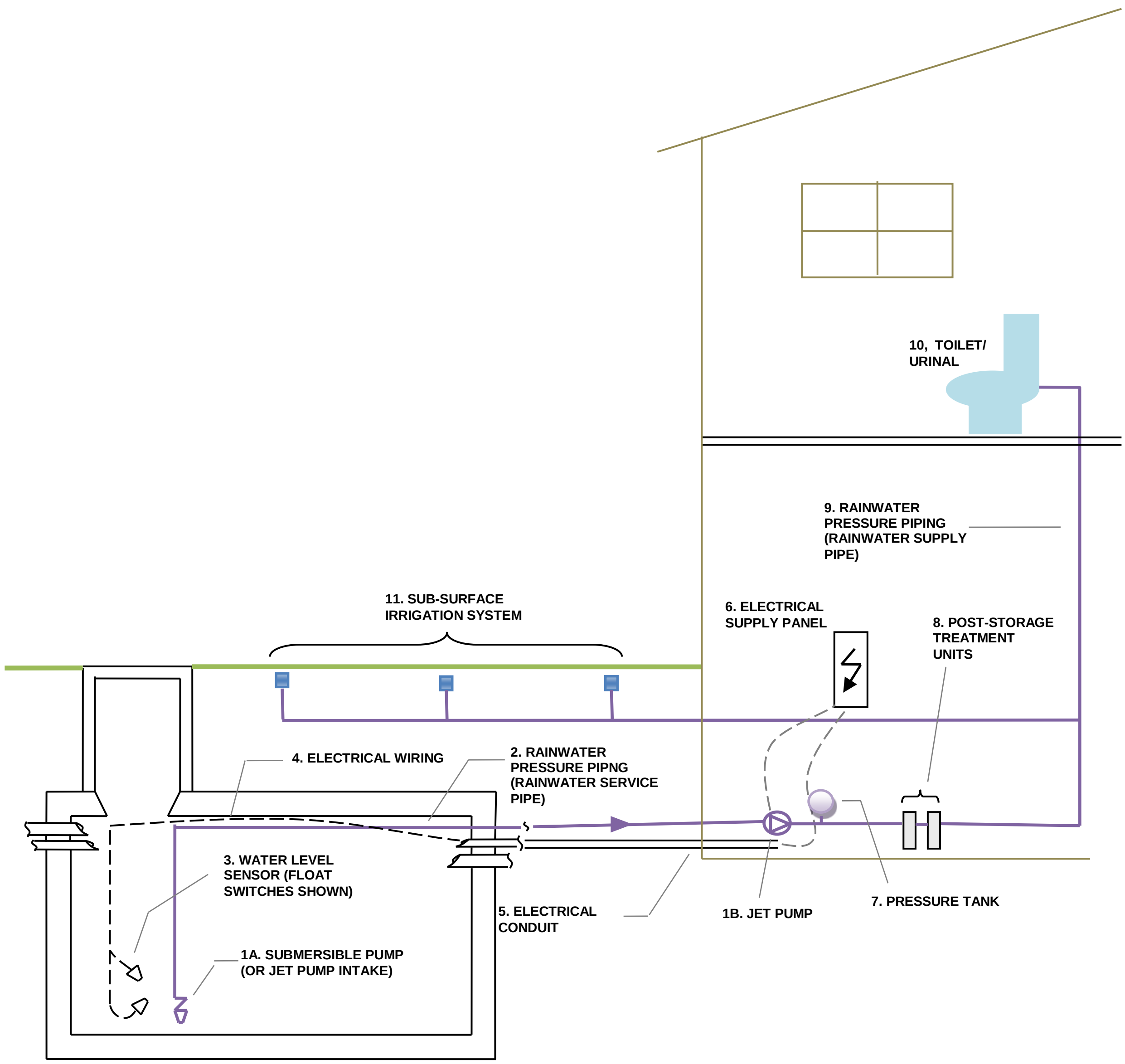

Figure 5-1. Typical schematic of pump and pressurized distribution system for below-ground rainwater tank

Pipes

As seen in Figure 5-1, there are two distinct sections of rainwater pressure piping:

1. **Rainwater service pipe** – the section of pipe from the storage tank to a jet pump, or the section of pipe from the storage tank to the pressure tank or control unit, in the case of submersible pumps;
2. **Rainwater supply pipe** – the section of pipe from the jet pump (or pressure tank/control unit for submersible pumps) to the permitted fixtures.

Each section has unique criteria that must be considered during design and installation, resulting in different pipe material, sizing and installation requirements. For instance, below-ground rainwater tanks require rainwater service pipe that is suitable for burial and, as this pipe will always have water in it, it is critical that it is well protected from freezing. Rainwater supply piping is inside the building and must be installed in accordance with codes to ensure that a cross-connection is not made. Both sections of pipes must be sized to handle the flow generated by the pump and ensure that each fixture receives rainwater at a sufficient rate, with service piping typically requiring larger pipe diameters than supply piping.

Markings

To prevent cross-connections, rainwater piping must be marked to indicate that the pipes contain non-potable water. Markings for pipe must be distinct and easily recognizable, typically a purple colour is used to identify the piping as containing non-potable water. An example of pipe marking is shown in Figure 5-2.

WARNING: NON-POTABLE WATER — DO NOT DRINK
AVERTISSEMENT : EAU NON-POTABLE — NE PAS BOIRE

Figure 5-2. Typical marking for rainwater pressure piping

Another means of identifying rainwater pressure piping is to utilize a distinct colour of pipe – purple – to prevent future plumbing cross-connections.

5.2 Applicable Codes, Standards, and Guidelines

Table 5-1 references specific codes and standards that are applicable to pressure systems.

Table 5-1. Applicable standards, codes and guidelines for pump and pressure distribution systems

Applicable Codes, Standards, and Guidelines	Selected Provisions & Design and Installation Implications
Alberta Building Code (2006)	• **7.2.1.2.(8) Plumbing Systems and Fixtures** Specifies that rainwater shall not be connected to plumbing fixtures that provide water for human consumption, cooking, cleaning, showering or bathing.
National Plumbing Code of Canada (2005)	• **2.2.5.5. Polyethylene Pipe and Fittings** • **2.2.5.7. Crosslinked Polyethylene Pipe and Fittings** • **2.2.5.8. PVC Pipe and Fittings** • **2.2.5.9. CPVC, Pipe, Fittings and Solvent Cements** • **2.2.7.1. Copper and Brass Pipe** • **2.3.4.5. Support for Horizontal Piping** • **2.6.3. Size and Capacity of Pipes** • **2.7.1.1. Not Permitted** • **2.7.2.1. Markings Required** • **2.7.3.2. Outlets** Articles 2.2.5.5., 2.2.5.7., 2.2.5.8., 2.2.5.9. and 2.2.7.1. specify approved pipe materials used for pressure applications. Article 2.3.4.5. provides specifications for the support of piping. Subsection 2.6.3. provides a method for sizing water distribution systems, as per Tables 2.6.3.1 and 2.6.3.2 and Table A-2.6.1.1.(1). Articles 2.7.1.1. and 2.7.2.1. specify that rainwater pressure pipes shall not be connected to potable water pipes and that rainwater shall not discharge into a sink, or where a potable outlet discharges or food/drink is prepared. Rainwater pressure piping shall have markings that are permanent and easily recognized, as per 2.7.2.1.
Canadian Electrical Code (Current ed.)	**All electrical equipment must be approved and installed to according to the requirements of the current edition Canadian Electrical Code**

Mandatory Documents   Supplementary Documents

Applicable Codes, Standards, and Guidelines	Selected Provisions & Design and Installation Implications
CSA Standard B128.1 (2006)	• **5 Installation Requirements** • **9 Pumps** • **10 Separation** • **11 Testing** • **12 Markings** Provides guidelines for the pipes, pumps and plumbing accessories used for RWH systems, separation of rainwater pipes and potable water pipes and testing for cross-connections, as well as the markings for rainwater service pipes and outlets.

Mandatory Documents Supplementary Documents

5.3 Design & Installation Guidelines

Design and installation guidelines:

> **Note**: refer to *Section 5.2 Applicable Codes, Standards, and Guidelines* for the specific provisions that apply when the term "in accordance with applicable provincial codes and regulations" is used.

1. Determine the fixtures connected to rainwater:
    a. In the Province of Alberta, rainwater may be used for:
        i. Toilet and urinal flushing, and
        ii. Sub-surface irrigation.
    b. Consult the applicable provincial codes and regulations to verify the fixtures for which connection to rainwater is permitted.
2. Select the pump:
    a. Determine the style and operating characteristics:
        i. Style: jet pump or submersible pump,
        ii. Controller configuration: constant speed or variable speed drive (VSD),
        iii. Operating voltage: 120V or 240V.
    b. Determine the required flow rate:
        i. Consult applicable codes and regulations, industry standards, local authorities and irrigation system manufacturer (if applicable) regarding the minimum flow rate to be supplied by the pump,
        ii. For guidance purposes only, a method for estimating minimum pump flow rate, based upon the maximum peak demand sizing method, is provided in *Appendix C*.
    c. Determine the pump head:
        i. Consult applicable codes and regulations regarding the minimum flow pressure and maximum static pressure provided by the pump,
        ii. A method for determining the pump head is provided in *Appendix C*.
    d. Consult the pump manufacturer or supplier, or use pump manufacturer's 'pump curve' charts, to select the appropriate pump model, given the pump style and operating characteristics, required flow rate, and pump head.
    e. If pump downtime is not permitted or not desired:
        i. Provide a generator or battery backup for the pump, and/or
        ii. Provide a backup pump or duplex pump arrangement.
3. Select the pressure tank:
    a. Consult the pump manufacturer or supplier regarding the minimum size of pressure tank for the pump, based upon pump controller configuration, and pump flow rate;
    b. For guidance purposes only, a method for sizing the pressure tank for constant speed pumps is provided in *Appendix C*.

4. Plan the layout of the pump and pressurized distribution system:
    a. Plan route of the rainwater service piping from the jet pump, pressure tank or control unit to the tank (refer to *Section 1.3 Design & Installation Guidelines* for guidelines and applicable provincial codes and regulations regarding installation of underground piping);
    b. Plan route of the rainwater supply piping from the jet pump, pressure tank or control unit to the permitted fixtures;
    c. Plan route of electrical conduit(s) from the location of the power supply to the tank (route with float switch wiring where possible, refer to *Chapter 4. Make-up Water System and Backflow Prevention* for further details);
    d. Ensure that there are no buried service lines (gas, electricity, water, stormwater, wastewater, phone, or cable lines) in the area where digging will take place to accommodate buried rainwater service piping and/or electrical conduit by contacting the municipality and service providers.
5. Rainwater pressure piping:
    a. Rainwater pressure piping is comprised of two distinct sections of pipe:
        i. Rainwater service pipe:
            1. Piping from the storage tank to a jet pump, or
            2. Piping from the storage tank to the pressure tank or control unit, in the case of submersible pumps.
        ii. Rainwater supply pipe:
            1. Piping from the jet pump (or pressure tank/control unit for submersible pumps) to the permitted fixtures.
    b. Rainwater service pipes:
        i. Pipe material:
            1. Polyethylene pipe (recommended), where
            2. Pipe selected must be approved by applicable provincial codes and industry standards (CSA, ASTM, etc.).
        ii. Pipe size:
            1. Pipe shall be sized to handle the maximum flow rate of the pump in accordance with the pump manufacturer’s instructions,
            2. For estimation purposes, service pipe size can be calculated using the method provided in *Appendix C*.
        iii. Tank connection:
            1. Rainwater service piping should enter the tank at a height no lower than that of the overflow drainage piping, or ideally, at a height 50 mm [2 in.] above the top of the overflow drainage pipe(s) entering the tank, or
            2. Where entering the tank at a height no lower than that of the overflow drainage piping exposes the rainwater service piping to frost, rainwater service piping may enter the tank at a lower height, provided the tank connection is water tight.
    c. Rainwater supply pipes:
        i. Pipe material:
            1. Crosslinked polyethylene (PEX) (recommended), where

        2. Pipe selected must be approved by applicable provincial codes and industry standards (CSA, ASTM, etc.).
    ii. Pipe size:
        1. Consult the applicable provincial codes and regulations pertaining to water supply pipe sizing,
        2. For estimation purposes, supply pipe size can be calculated using the method provided in *Appendix C*.

6. Installation of rainwater pressure piping:
    a. Connection:
        i. Rainwater pressure piping shall not be connected to a potable water system,
        ii. Rainwater pressure piping shall only connect to fixtures permitted by applicable provincial codes and regulations.
    b. Support and protection:
        i. Underground piping shall be located in a properly excavated space, be supported and properly backfilled in accordance with applicable provincial codes and regulations,
        ii. Piping inside a building shall be supported in accordance with applicable provincial codes and regulations,
        iii. Piping shall be protected from frost (refer to *Section 1.3 Design & Installation Guidelines* for details).
    c. Operation and maintenance considerations:
        i. Rainwater service piping connected to a jet pump must be installed on a horizontal, or on a consistent upward slope from the storage tank to the pump,
        ii. To minimize the possibility of leaks, underground rainwater service piping should be installed with no, or few, pipe fittings,
        iii. To facilitate repair and/or replacement of underground rainwater service piping, piping should be installed inside a rainwater service conduit, where the conduit material can be flexible drainage tubing (typically referred to as "Big 'O' " tubing) or other suitable material.
    d. Underground non-metallic pipes should be installed with 'tracer tape' (also referred to as 'tracer wire') at a height of 300 mm [12 in.] above the pipe for the purpose of locating as-installed piping.
7. Pipe markings[8] :
    a. All rainwater pressure pipes shall be clearly identified and marked in accordance with applicable provincial codes and regulations;
    b. Pipes shall be marked as follows:
        i. Text/legend:
            1. WARNING: NON-POTABLE WATER — DO NOT DRINK
               AVERTISSEMENT : EAU NON-POTABLE — NE PAS BOIRE
            2. Text must be legible with letters no less than 5 mm in height, except where pressure pipe size makes 5 mm high letters impractical.

[8] Adapted from CAN/CSA-B128.1-06 Design and installation of non-potable water systems. 2006. CSA International, Mississauga, ON. Refer to CAN/CSA-B128.1-06 for further details.

    ii. Colour:
        1. Marking labels shall be purple in colour, and/or
        2. Pipes shall be purple in colour, or marked with a continuous purple stripe.
    iii. Figure 5-3 provides an example of typical pipe marking:

WARNING: NON-POTABLE WATER — DO NOT DRINK
AVERTISSEMENT : EAU NON-POTABLE — NE PAS BOIRE

Figure 5-3. Typical marking for rainwater pressure piping

  c. Spacing of markings:
    i. Markings shall be repeated at intervals of not more than 1.5 m.

8. Installation of pump :
  a. Pumps shall be installed in accordance with the manufacturer's installation instructions;
  b. Pumps shall be installed such that they are readily accessible (submersible pumps must be retrievable without entry into the tank);
  c. Pump shall be provided with dry run protection. Consult pump specifications to determine if pump has built-in dry run protection, if not, provide a water level sensor (refer to *Chapter 4. Make-up Water System and Backflow Prevention* for details);
  d. For jet pumps:
    i. Rainwater service pipe should terminate no less than 100-150 mm [4-6 in.] above the bottom of the tank,
    ii. Pump prime shall be maintained by a foot valve located at the rainwater service pipe intake, or a check valve located in the rainwater service pipe upstream of the jet pump.
  e. For submersible pumps:
    i. The pump intake should be located no less than 100-150 mm [4-6 in.] above the bottom of the tank,
    ii. Pump prime shall be maintained a check valve located in the rainwater service pipe downstream of the jet pump (consult pump manufacturer's instructions to determine if required).
  f. Electrical requirements:
    i. All wiring must be installed in accordance with the current edition Canadian Electrical Code. Refer to the pump manufacturer's installation instructions for further details,
    ii. Electrical wiring installed outdoors and/or underground should be provided with protection,
    iii. The pump should be installed on a dedicated circuit, with a motor disconnect switch installed near the pressure tank or control panel (refer to the Canadian Electrical Code for specifics),
    iv. For buried tanks, electrical wiring should be suitable for burial and/or wiring should be run through a protective conduit made of PVC pipe, or 'Big-O'-style drainage pipe,

v. Buried electrical wiring and/or conduits should be installed in a properly prepared and backfilled space (refer to *Chapter 1. Rainwater Catchment & Conveyance* for details).

9. Installation of pressure tank:
   a. Pressure tanks shall be installed in accordance with the manufacturer's installation instructions;
   b. Pressure tanks shall be installed such that they are readily accessible;
   c. Pressure tanks shall be installed with a means for observing the system pressure, such as a pressure gauge;
   d. The pressure sensor or pressure switch installed with the pressure tank must be wired in with the pump (and a control panel if applicable);
   e. All wiring must be installed in accordance with the current edition Canadian Electrical Code.
10. Install post-storage treatment devices as required (refer to *Chapter 3. Rainwater Quality & Treatment* for details).
11. Commission the pump and pressurized distribution system in accordance with the manufacturer's instructions.

Chapter 6. Overflow Provisions & Stormwater Management

6.1 Introduction

On occasion, the volume of rainwater collected from the roof catchment will exceed the storage capacity of the rainwater storage tank, causing the tank to overflow. If overflow-handling provisions are not in place, excess rainwater will back up rainwater conveyance and top-up drainage piping, until the rainwater reaches a point from which it can most easily discharge/overflow. This may be at the downspout-to-conveyance pipe transition, or less ideal locations like the access opening of the tank, or at the air gap of a top-up system. Overflows at these points may cause damage to the rainwater tank itself, or cause water damage to a building's exterior or interior.

Excess rainwater can be directed to grade, to the storm sewer, or to on onsite infiltration system (soakaway pit), depending on the characteristics of the site. Ideally overflow volumes can be conveyed via gravity, but if the tank outlet is located below the storm sewer or grade, pumping may be required.

The advantages and disadvantages of the different systems are discussed in Table 6-1.

Table 6-1. Comparison of the advantages and disadvantages associated with overflow discharge locations/methods

Overflow Discharge Locations/Methods	Advantages	Disadvantages
Discharge to grade via gravity flow ***(most recommended)***	• Simplest method to design, install and operate. • Low probability of rainwater backing up the overflow drainage piping	• If discharge location not prepared properly, may cause soil erosion at site. • May pose a nuisance/safety issue if discharging large volumes from big catchment surfaces. • Overflow drainage piping may freeze if large sections are above the frost penetration depth; ice may build up at the point of discharge if not designed properly.
Discharge to storm sewer via gravity flow	• Ideal for below-ground tanks as storm-sewers are also located below grade. • Storm sewers are specifically designed to collect roof runoff and direct it to an appropriate location off-site.	• Design must prevent backflow from storm sewer into rainwater tank. • Stormwater discharges can have negative environmental impacts on receiving water bodies.
Discharge to soakaway pit via gravity flow	• Permits the handling of stormwater on-site, which contributes to maintaining pre-development drainage regimes. • Environmental benefits of groundwater recharge. • In newer housing developments, an infiltration trench, serving multiple lots, may be built by the developer.	• Soakaway pits require extensive site work to design and install (high in cost). • Large rainfall events can exceed the infiltration capacity of the soil, requiring a separate overflow from the soakaway pit • Suitable only for permeable soils
Discharge to grade or storm sewer via pump-assisted flow ***(least recommended)***	• In cases where the tank is located deep underground (building sub-basements, parking garages, etc.) this may be the only method of handling overflows.	• Pump may fail in the event of a power outage. • Large pump required to handle overflow volumes generated during intense rainfall events.

In addition to the advantages and disadvantages discussed in Table 6-1, selection of an overflow discharge location must also consider:

1. Site-specific stormwater management requirements (i.e., for retention, infiltration and/or slow release);
2. Applicable provincial and municipal regulations;
3. Location/placement of rainwater storage tank; and
4. Site conditions (i.e., grade, topography, space availability, infiltration capacity of soil).

Rainwater Harvesting for Stormwater Detention & Retention

A rainwater tank can also be used in place of a holding tank for detention and controlled release, for stormwater management purposes. As shown in Figure 6-1, the bottom portion of the tank stores rainwater for later use, and the top portion of the tank temporarily detains the rainwater and releases it at a predetermined rate through control valves. Excess volumes from extreme events are discharged through the overflow drainage piping.

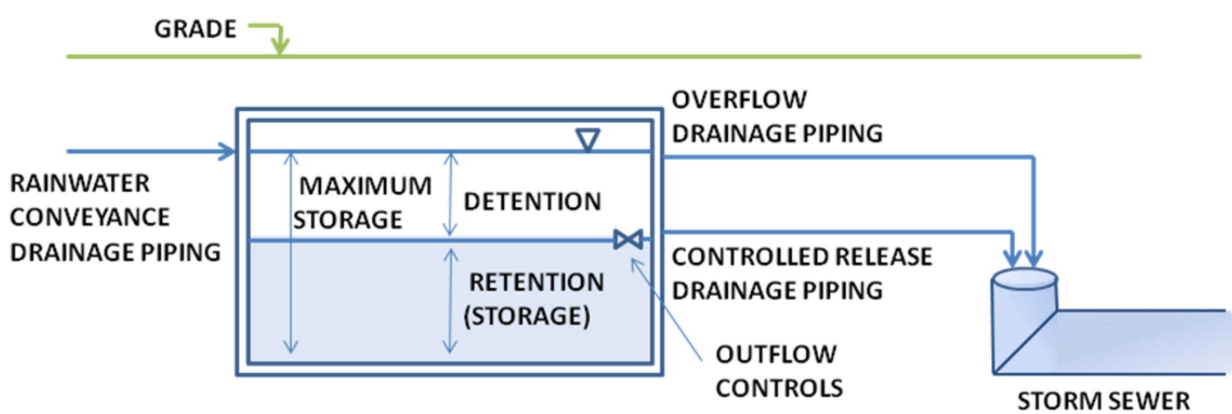

Figure 6-1. Schematic of RWH system with outflow controls and controlled release drainage piping for stormwater management. ('DETENTION' is the volume of runoff to be slowly released to storm sewer. The remaining volume 'RETENTION' is used to supply rainwater to permitted fixtures

For further guidelines on sizing a rainwater storage tank for both detention and retention, refer to *Appendix D.*

6.2 Applicable Codes, Standards, and Guidelines

Table 6-2 references specific codes and standards that are applicable to overflow-handling systems.

Table 6-2. Applicable standards, codes and guidelines for rainwater overflow handling systems

Applicable Codes, Standards, and Guidelines	Selected Provisions & Design and Installation Implications
National Plumbing Code of Canada (2005)	• **2.4.2.2. Connection of Overflows from Rainwater Tanks** Specifies that an overflow from a rainwater tank shall not be directly connected to a drainage system (an indirect connection is required). *Note: Overflow drainage pipes must be sized and installed in accordance with the NPC provisions applicable to drainage piping. See Chapter 1 for details.*
CSA Standard B128.1 (2006)	• **7.7 Overflow(s) capacity** • **7.8 Overflow discharge** Specifies that the capacity of the overflow drainage pipe(s) must be equal to the capacity of the conveyance drainage pipes, and that overflows must be discharged in accordance with local regulations.
Stormwater Management Guidelines for the Province of Alberta (1999)	• **6.3.3 On-lot Infiltration Systems** Provides brief description of lot-level infiltration systems.
Alberta Private Sewage Systems Standard of Practice (2009)	• **7.1.1.2. Site Evaluation (2), (3)** • **7.1.2.1. Number of Soil Profiles Investigated** • **7.1.2.2. Minimum Depth of Soil Investigation** Provides guidelines on evaluating site soil profiles, which can be used in the sizing of soakaway pits/infiltration trenches.

Mandatory Documents   Supplementary Documents

6.3 Design & Installation Guidelines

Design and installation guidelines:

Note: refer to *Section 6.2 Applicable Codes, Standards, and Guidelines* for the specific provisions that apply when the term "in accordance with applicable provincial codes and regulations" is used.

1. Determine the overflow discharge location and method:
    a. Overflow discharge locations include: grade, storm sewer, or soakaway pit;
    b. Overflow discharge methods include: gravity flow or pump-assisted flow;
    c. Overflow by pump-assisted flow is not recommended;
    d. Consult the applicable provincial codes and regulations, municipal bylaws, and local authorities regarding the permitted overflow discharge locations;
    e. Evaluate the feasibility of the overflow discharge locations:
        i. Overflow to grade:
            1. The overflow discharge location must be at a lower elevation than the flood level rim of the tank for gravity flow to be feasible.
        ii. Overflow to storm sewer:
            1. A storm sewer connection must be present at the site,
            2. The overflow discharge location must be at a lower elevation than the flood level rim of the tank for gravity flow to be feasible.
        iii. Overflow to soakaway pit:
            1. The percolation rate of site soils must be sufficient to permit infiltration of rainwater overflows discharged into the soakaway pit (refer to *Appendix D* for guidelines on performing a site soil assessment and sizing soakaway pits).
2. Plan the layout of the overflow system:
    a. Plan route of overflow drainage piping from the tank to the overflow discharge location (refer to *Section 1.3 Design & Installation Guidelines* for guidelines and applicable provincial codes and regulations regarding drainage piping);
    b. Ensure that there are no buried service lines (gas, electricity, water, stormwater, wastewater, phone, or cable lines) in the area where digging will take place to accommodate buried overflow drainage piping by contacting the municipality and service providers.
3. Overflow pipes:
    a. Overflow drainage pipes:
        i. Pipe material:
            1. PVC SDR35 pipe (recommended), or ABS pipe, where
            2. Pipe selected must be approved by applicable provincial codes and industry standards (CSA, ASTM, etc.).
        ii. Pipe size and slope:
            1. Overflow drainage piping shall be sized to ensure that the capacity of overflow drainage pipe(s) are no less than the capacity of the rainwater conveyance drainage pipe(s),
            2. Ensure a minimum slope of 0.5-2% (the greater the slope the better) is maintained throughout the pipe length,

iii. Tank connection:
    1. Overflow drainage piping shall exit the tank at a height no lower than that of the rainwater conveyance drainage piping, or ideally, at a height 50 mm [2 in.] below the bottom of the conveyance drainage pipe(s) entering the tank.

iv. Consult the applicable provincial codes and regulations pertaining to the installation of drainage piping (refer to *Section 1.2 Applicable Codes, Standards, and Guidelines* for details).

b. Overflow pressure pipes:
    i. Pipe material:
        1. Polyethylene pipe (recommended), where
        2. Pipe selected must be approved by applicable provincial codes and industry standards (CSA, ASTM, etc.).
    ii. Pipe size and slope:
        1. Overflow pressure piping shall be sized to ensure that the capacity of overflow pressure pipe(s) are no less than the capacity of the rainwater conveyance drainage pipe(s).
    iii. Consult the applicable provincial codes and regulations pertaining to the installation of pressure piping (refer to *Section 5.2 Applicable Codes, Standards, and Guidelines* for details).

4. Discharging overflows to grade:
    a. Overflows must be discharged in a location where rainwater won't pond or collect around building foundations;
    b. Erosion prevention measures should be taken;
    c. A screen should be installed where the pipe terminates to prevent the entry of birds, rodents or insects.
5. Discharging overflows to storm sewer:
    a. Overflow drainage piping cannot be directly connected to a storm sewer, unless approved by local authorities;
    b. A direct connection may be permitted if a backwater valve is installed on the overflow drainage pipe. Consult local authorities for approval;
    c. An indirect connection can be made by overflowing:
        i. To an interceptor tank, which then overflows to storm sewer,
        ii. To a soakaway pit, which then overflows to the storm sewer,
        iii. Via overland flow to a sewer grate, or
        iv. Using an air gap, in the case of above ground tanks.
6. Discharging overflows to a soakaway pit:
    a. Consult applicable provincial and municipal guidelines regarding the design and installation of soakaway pits;
    b. For guidance purposes only, soakaway pit design and installation guidelines are provided in *Appendix D*;
    c. If there is limited space for a soakaway pit or if the soil has a low permeability, it is recommended that the soakaway pit have its own overflow, discharging overflows to grade or storm sewer.

7. Overflow discharge pump:
    a. If rainwater overflows must be pumped, the pump shall be sized to handle the capacity of the rainwater conveyance drainage pipe(s);
    b. The pump shall be selected and installed in accordance with the guidelines provided in *Chapter 5. Pump and Pressurized Distribution System*.
8. Incorporating a RWH system as part of a stormwater management system:
    a. Consult the municipality and/or conservation authority regarding how to incorporate a RWH system into other stormwater management systems;
    b. If considering utilizing a rainwater storage tank for both retention and detention purposes, refer to *Appendix D* for further details.

Appendix

Appendix A. Rainwater Catchment & Conveyance

Collection Losses from Roof Surfaces
Sizing Gutters and Downspouts
Sizing Rainwater Conveyance Drainage Piping
Frost Penetration Depth & Pipe Freeze Protection

Appendix B. Rainwater Storage & Tank Sizing

Rainwater Harvesting Design Tool
Rainwater Storage Tank Sizing Table

Appendix C. Pump and Pressurized Distribution System

Calculation of Required Pump Capacity
Calculation of Required Pressure from Pump (Pump Head)
Calculation of Friction Loss
Calculation of Pressure Tank Size
Calculation of Pipe Size

Appendix D. Overflow Provisions & Stormwater Management

Utilizing a Rainwater Storage Tank for Retention & Detention for Stormwater Management Purposes
Design & Sizing of Soakaway Pits
Assessment of Site Soil Infiltration Loading Rate (Percolation Rate)

Appendix A. Rainwater Catchment & Conveyance

Collection Losses from Roof Surfaces

Although 1 L of runoff can theoretically be collected from each millimetre of rainfall contacting a 1 m^2 area, some losses take place following contact with the catchment surface. These losses vary depending upon the type of catchment material and the geometry of the roof and should be considered when estimating the amount of rainwater that can be collected by the RWH system. Losses for various roof catchment materials are listed in Table A-1.

Table A-1. Collection efficiency (loss factors) associated with various roof catchments[9, 10]

Roof Catchment Material	Initial Rainfall Loss Factor (mm)	Continuous Rainfall Loss Ratio (%)
Steel Roof	0.25	20.0
Asphalt Shingle Roof	0.5	20.0
Fiberglass Roof	0.5	20.0
Asphalt Built-up Flat Roof	1.5	20.0
Hypalon (Rubber) Flat Roof	1.5	20.0

Sizing Gutters and Downspouts

Note: the guidelines for sizing gutters and downspouts provided in Section 1.3 Design & Installation Guidelines are reproduced below to assist with following the example provided. The detailed example is located following the reproduced guidelines.

1. To determine the size of gutter required for a given roof drainage area:
    a. Consult the applicable provincial codes and regulations pertaining to the design rainfall intensity for the site location (refer to *Section 1.2 Applicable Codes, Standards, and Guidelines* for details);
    b. Calculate the area of roof draining into the gutter:

$$\boldsymbol{Roof\ Drainage\ Area}\ (\mathbf{m^2}) = Length\ (\mathrm{m}) \times Width\ (\mathrm{m})$$

Equation A-1

Where: Length = length of the gutter served by a downspout (m)
Width = distance from the eave to the ridge of the roof drainage area served (m)

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[9] DIN 1989-1:2001-10. DIN 1989 Rainwater Harvesting Systems - Part 1: Planning, Installation, Operation and Maintenance. 2002. Fachvereinigung Betriebs- und Regenwassernutzung e.V, fbr, Darmstadt, Germany

[10] Building Capacity for Rainwater Harvesting in Ontario: Rainwater Quality and Performance of RWH Systems. 2008. Despins, C. M.Sc. Thesis, University of Guelph.

c. Refer to Table A-2 to determine the minimum size of gutter, required based upon the roof drainage area (m^2) and design rainfall intensity values determined above:

Table A-2. Minimum gutter sizes for given roof drainage areas and rainfall intensities[11]

Minimum Required Gutter Size and Type	Maximum Roof Drainage Area Served per Downspout (m^2)[1,2] Design Rainfall Intensity (15 Min rainfall, mm):							
	18.75	25	31.25	37.5	43.75	50	56.25	62.5
100 mm [4 in.] K-style	71	53	43	35	30	27	24	21
125 mm [5 in.] K-style	130	98	78	65	56	49	43	39
150 mm [6 in.] K-style	212	159	127	106	91	79	71	64

[1] Minimum required gutter size assumes that gutters have a minimum slope (≤ 6.25%). For greater gutter slopes, the table values may be multiplied by 1.1.
[2] Maximum roof drainage area assumed roof slopes ≤ 5:12. For steeper roof pitches, multiply the table values by 0.85.

d. For other gutter types and/or larger roof drainage areas, consult the gutter manufacturer or contractor regarding the sizing of gutter.

2. To determine the size of downspout required:
   a. Refer to Table A-5 to determine the minimum size of downspout (either rectangular- or square type) based upon the size of gutter the downspout is serving:

Table A-3. Minimum downspout sizes for given size of gutter[12]

Gutter Size and Type	Minimum Downspout Size (mm [in])	
	Rectangular type	Square-type
100 mm [4 in.] K-style	50x75 [2x3]	75x75 [3x3]
125 mm [5 in.] K-style	50x75 [2x3]	75x75 [3x3]
150 mm [6 in.] K-style	75 x 100 [3x4]	100x100 [4x4]

   b. For other downspout types and/or larger gutter sizes, consult the gutter/downspout manufacturer or contractor regarding the sizing of downspout.

[11] Adapted from Moisture Resistant Homes: A Best Practice Guide and Plan Review Tool for Builders and Designers. 2006. U.S. Department of Housing and Urban Development, Washington, DC.
[12] Adapted from Moisture Resistant Homes: A Best Practice Guide and Plan Review Tool for Builders and Designers. 2006. U.S. Department of Housing and Urban Development, Washington, DC.

3. Example:

For a residential house located in Edmonton, AB with a roof with the peaks and roof pitch illustrated in Figure A-1 and Figure A-2:

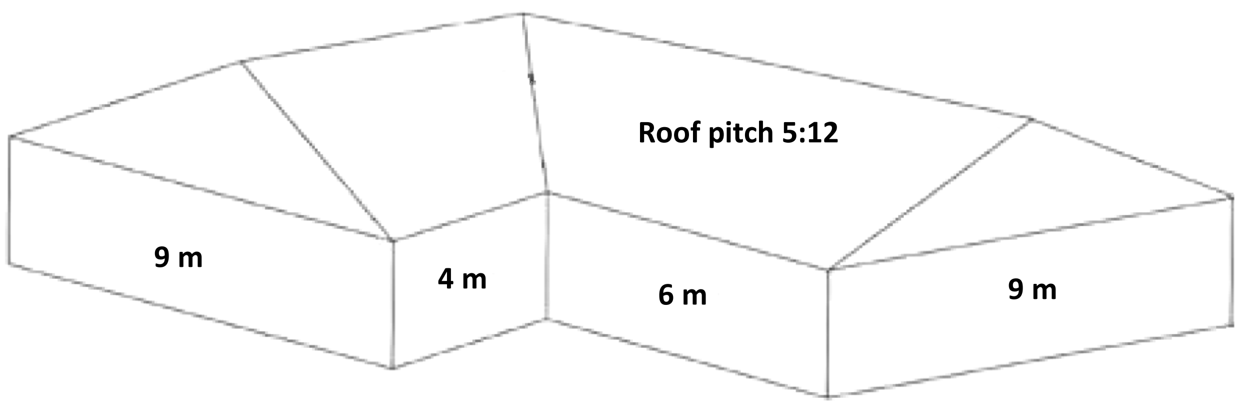

Figure A-1. Roof drainage area to be guttered (isometric 'facing' view)[13]

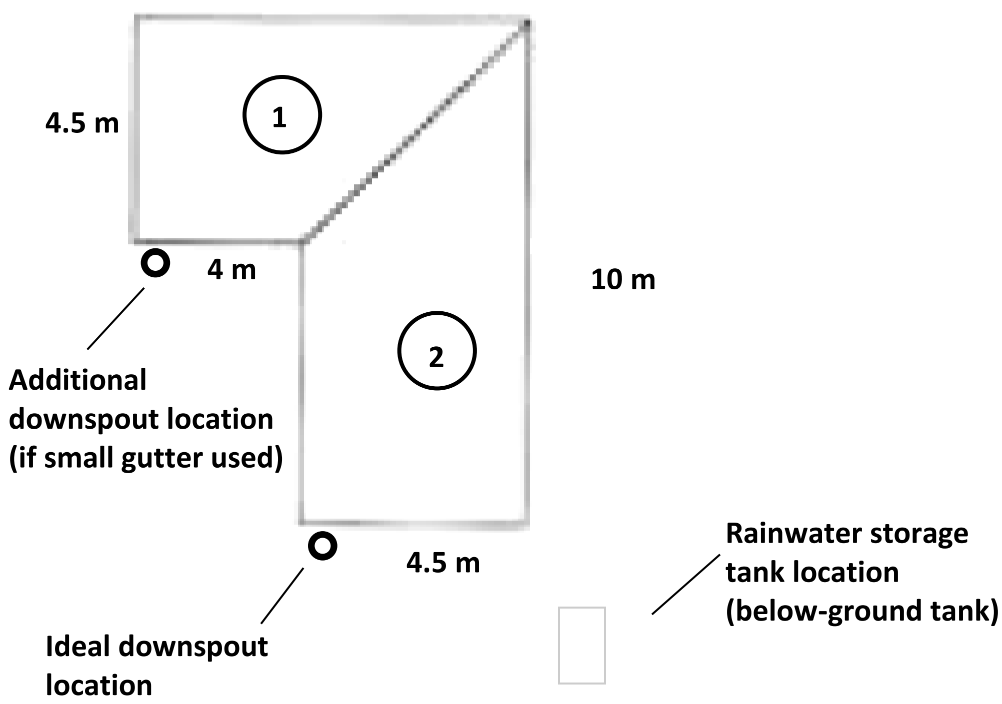

Figure A-2. Roof drainage area to be guttered (projected 'top-down' view)[14]

[13] Adapted from Moisture Resistant Homes: A Best Practice Guide and Plan Review Tool for Builders and Designers. 2006. U.S. Department of Housing and Urban Development, Washington, DC.
[14] Adapted from Moisture Resistant Homes: A Best Practice Guide and Plan Review Tool for Builders and Designers. 2006. U.S. Department of Housing and Urban Development, Washington, DC.

From the Alberta Building Code 2006 Division B , Appendix C - Table C-2 (refer to *Section 1.2 Applicable Codes, Standards, and Guidelines* for details):

Design rainfall intensity (15 Min rainfall, mm): 23

To calculate the roof drainage area:

$$\boldsymbol{Roof\ Drainage\ Area} = Area\ 1 + Area\ 2$$

$$Area\ 1 = 4\ \mathrm{m} \times 4.5\ \mathrm{m}$$
$$Area\ 1 = 18\ \mathrm{m}^2$$

$$Area\ 2 = 4.5\ \mathrm{m} \times 10\ \mathrm{m}$$
$$Area\ 2 = 45\ \mathrm{m}^2$$

$$\boldsymbol{Roof\ Drainage\ Area} = Area\ 1 + Area\ 2$$
$$\boldsymbol{Roof\ Drainage\ Area} = 18\ \mathrm{m}^2 + 45\ \mathrm{m}^2$$
$$\boldsymbol{Roof\ Drainage\ Area} = \mathbf{63\ m^2}$$

Referring to Table A-2 (reproduced from Table 1-2), the maximum roof drainage area for this section of roof is given in the second column (23 mm rainfall intensity for the City of Edmonton – rounded up to 25 mm).

To discharge the entire roof drainage area to one downspout:

Referring to the second column of Table A-2, a 100 mm [4 in.] K-style gutter can only be used to convey rainwater from roof areas of up to 53 m^2. This area, however, is less than the drainage area calculated for this residential household – 63 m^2.

By selecting a larger gutter – a 125 mm [5 in.] K-style gutter – all of the drainage area can be discharged to one downspout as this gutter size can convey rainwater from an area of up to 78 m^2 (> 63 m^2).

Referring to Table A-3 (reproduced from Table 1-3), a 125 mm [5 in.] K-style gutter requires a 50x75 mm [2x3 in.] rectangular-type downspout, or a 75x75 mm [3x3 in.] square-type downspout.

To minimize the length of conveyance drainage piping required, the downspout should be located as close as possible to the rainwater storage tank. The ideal location of the downspout is illustrated in Figure A-2.

To discharge the roof drainage area to more than one downspout:

Referring to the second column of Table A-2, a 100 mm [4 in.] K-style gutter can be used – but additional downspouts are required because the roof drainage area considered is greater than the maximum roof drainage area served per downspout (by one downspout).

To calculate the number of downspouts required:

$$\boldsymbol{Number\ of\ Downspouts} = \frac{Roof\ Drainage\ Area}{Max. Roof\ Drainage\ Area\ Served\ Per\ Downspout}$$

$$\boldsymbol{Number\ of\ Downspouts} = \frac{63\ \mathrm{m}^2}{53\ \mathrm{m}^2}$$

$$\boldsymbol{Number\ of\ Downspouts} = \mathbf{1.2}\ (\textbf{round up to 2})$$

By selecting a smaller gutter – a 100 mm [4 in.] K-style gutter – the drainage area must be discharged to 1.2 downspouts (rounded up to 2 downspouts).

Referring to Table A-3 (reproduced from Table 1-3), a 100 mm [4 in.] K-style gutter requires a 50x75 mm [2x3 in.] rectangular-type downspout, or a 75x75 mm [3x3 in.] square-type downspout.

In addition to the one downspout located close to the rainwater storage tank (shown in Figure A-2 as the 'ideal downspout location'), a second downspout is required. Locating downspouts on interior building corners is not recommended, thus, it should be placed at the corner closest to the rainwater storage tank (see Figure A-2).

Sizing Rainwater Conveyance Drainage Piping

1. Table A-4 and Table A-5 can be used to estimate the size of conveyance drainage pipes for different catchment areas:

Table A-4. Conveyance drainage pipe size requirements for roof areas 50-950 m^2 in Alberta cities[15]

<table>
<tr><th rowspan="2">City</th><th colspan="20">Roof Area (m^2)</th></tr>
<tr><th>0</th><th>50</th><th>100</th><th>150</th><th>200</th><th>250</th><th>300</th><th>350</th><th>400</th><th>450</th><th>500</th><th>550</th><th>600</th><th>650</th><th>700</th><th>750</th><th>800</th><th>850</th><th>900</th><th>950</th></tr>
<tr><td>Lethbridge</td><td colspan="5">4</td><td colspan="8">6</td><td colspan="7">8</td></tr>
<tr><td>Medicine Hat</td><td colspan="4">4</td><td colspan="7">6</td><td colspan="9">8</td></tr>
<tr><td>Calgary</td><td colspan="4">4</td><td colspan="7">6</td><td colspan="9">8</td></tr>
<tr><td>Banff</td><td colspan="5">4</td><td colspan="9">6</td><td colspan="6">8</td></tr>
<tr><td>Drumheller</td><td colspan="5">4</td><td colspan="8">6</td><td colspan="7">8</td></tr>
<tr><td>Red Deer</td><td colspan="4">4</td><td colspan="7">6</td><td colspan="9">8</td></tr>
<tr><td>Camrose</td><td colspan="5">4</td><td colspan="8">6</td><td colspan="7">8</td></tr>
<tr><td>Edmonton</td><td colspan="4">4</td><td colspan="7">6</td><td colspan="9">8</td></tr>
<tr><td>Jasper</td><td colspan="9">4</td><td colspan="11">6</td></tr>
<tr><td>Lloydminster</td><td colspan="5">4</td><td colspan="9">6</td><td colspan="6">8</td></tr>
<tr><td>Slave Lake</td><td colspan="6">4</td><td colspan="11">6</td><td colspan="3">8</td></tr>
<tr><td>Grande Prarie</td><td colspan="4">4</td><td colspan="7">6</td><td colspan="9">8</td></tr>
<tr><td>Fort McMurray</td><td colspan="7">4</td><td colspan="13">6</td></tr>
</table>

Legend

4" Pipe

6" Pipe

8" Pipe

10" Pipe

12" Pipe

15" Pipe

[15] Adapted from Alberta Building Code. 2006. Alberta Ministry of Municipal Affairs, Edmonton, AB. Adapted from National Plumbing Code of Canada. 2005. National Research Council of Canada, Ottawa, Ontario. Assumes 1% pipe slope.

Table A-5. Conveyance drainage pipe size requirements for roof areas 1000-3000 m^2 in Alberta cities[16]

<table>
<tr><th rowspan="2">City</th><th colspan="20">Roof Area (m^2)</th></tr>
<tr><th>1000</th><th>1100</th><th>1200</th><th>1300</th><th>1400</th><th>1500</th><th>1600</th><th>1700</th><th>1800</th><th>1900</th><th>2000</th><th>2100</th><th>2200</th><th>2300</th><th>2400</th><th>2500</th><th>2600</th><th>2700</th><th>2800</th><th>2900</th></tr>
<tr><td>Lethbridge</td><td colspan="4">8</td><td colspan="11">10</td><td colspan="5">12</td></tr>
<tr><td>Medicine Hat</td><td colspan="2">8</td><td colspan="10">10</td><td colspan="8">12</td></tr>
<tr><td>Calgary</td><td colspan="2">8</td><td colspan="10">10</td><td colspan="8">12</td></tr>
<tr><td>Banff</td><td colspan="5">8</td><td colspan="12">10</td><td colspan="3">12</td></tr>
<tr><td>Drumheller</td><td colspan="4">8</td><td colspan="11">10</td><td colspan="5">12</td></tr>
<tr><td>Red Deer</td><td colspan="2">8</td><td colspan="10">10</td><td colspan="8">12</td></tr>
<tr><td>Camrose</td><td colspan="4">8</td><td colspan="11">10</td><td colspan="5">12</td></tr>
<tr><td>Edmonton</td><td colspan="2">8</td><td colspan="10">10</td><td colspan="8">12</td></tr>
<tr><td>Jasper</td><td colspan="3">6</td><td colspan="14">8</td><td colspan="3">10</td></tr>
<tr><td>Lloydminster</td><td colspan="5">8</td><td colspan="12">10</td><td colspan="3">12</td></tr>
<tr><td>Slave Lake</td><td colspan="8">8</td><td colspan="12">10</td></tr>
<tr><td>Grande Prarie</td><td colspan="2">8</td><td colspan="10">10</td><td colspan="8">12</td></tr>
<tr><td>Fort McMurray</td><td colspan="11">8</td><td colspan="9">10</td></tr>
</table>

Legend

- 4" Pipe
- 6" Pipe
- 8" Pipe
- 10" Pipe
- 12" Pipe
- 15" Pipe

[16] Adapted from Alberta Building Code. 2006. Alberta Ministry of Municipal Affairs, Edmonton, AB. Adapted from National Plumbing Code of Canada. 2005. National Research Council of Canada, Ottawa, Ontario. Assumes 1% pipe slope.

Frost Penetration Depth & Pipe Freeze Protection

1. Local frost penetration depths for can be estimated using the following method:
    a. Locate the site on the map in Figure A-3 and identify the nearest contour line and its associated freezing index value (given in degree days);
    b. Estimate the frost penetration depth by correlating the degree-day value from Figure A-3 to the corresponding depth in Table A-6:

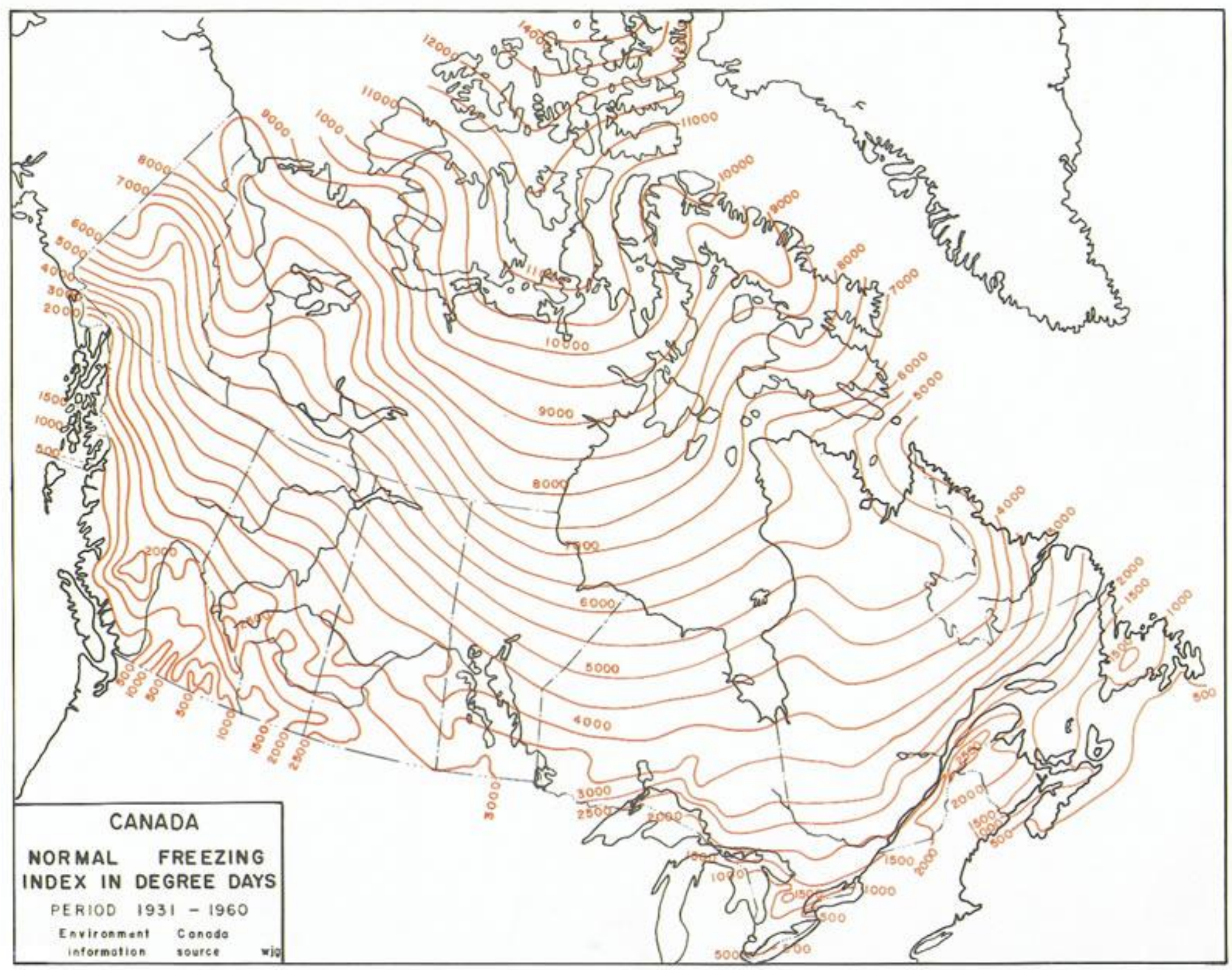

Figure A-3. Normal freezing index for Canada in degree days[17]

[17] Adapted from Canada Normal Freezing Index in Degree Days, Period 1931-1960. Environment Canada, Ottawa, ON.

Table A-6. Approximate frost depths associated with various freezing index values[18]

Freezing Index (Degree Days)	Frost Depth (m)	Freezing Index (Degree Days)	Frost Depth (m)
400	0.66	**2000**	1.98
450	0.71	**2050**	2.01
500	0.76	**2100**	2.04
550	0.81	**2150**	2.07
600	0.86	**2200**	2.1
650	0.91	**2250**	2.13
700	0.96	**2300**	2.16
750	1	**2350**	2.19
800	1.05	**2400**	2.22
850	1.09	**2450**	2.25
900	1.14	**2500**	2.28
950	1.18	**2550**	2.31
1000	1.21	**2600**	2.34
1050	1.25	**2650**	2.36
1100	1.29	**2700**	2.39
1150	1.32	**2750**	2.42
1200	1.36	**2800**	2.45
1250	1.39	**2850**	2.48
1300	1.43	**2900**	2.51
1350	1.47	**2950**	2.52
1400	1.5	**3000**	2.54
1450	1.54	**3050**	2.56
1500	1.57	**3100**	2.59
1550	1.62	**3150**	2.62
1600	1.66	**3200**	2.64
1650	1.7	**3250**	2.67
1700	1.74	**3300**	2.69
1750	1.78	**3350**	2.72
1800	1.82	**3400**	2.74
1850	1.86	**3450**	2.77
1900	1.9	**3500**	2.79
1950	1.94	**4000**	2.8

[18] Adapted from Ambient Temperatures – Below Ground (Frost Depth). 2009. Urecon Ltd., St. Lazare-de-Vaudreuil, Quebec.

2. To plan the layout of conveyance drainage piping for rainwater storage tanks located below grade:
    a. Determine the location of the tank (refer to *Chapter 2. Rainwater Storage & Tank Sizing* for guidance);
    b. Determine the frost penetration depth by consulting local building authorities regarding regulations or 'rules of thumb' for frost penetration depths. For estimation purposes, refer to the above methods in *Appendix A*;
    c. Where possible, rainwater conveyance drainage pipes and the storage tank should be buried below the frost penetration depth, otherwise additional freeze protection measures, such as insulation shall be required;
    d. To determine if the conveyance drainage pipes can be buried below the frost penetration depth:
        i. Determine the final pipe burial depth (D_f), where this depth depends upon:
            1. The local frost penetration depth, and
            2. The maximum rated burial depth of the rainwater storage tank,
            3. Where D_f shall be the lesser of the two values (i.e., if the tank cannot be buried below the frost penetration depth due to tank burial depth restrictions, then D_f shall be equal to the tank's max. rated burial depth).
        ii. Determine the initial pipe burial depth (D_i), where this depth depends upon:
            1. The total length of pipe,
            2. The slope of pipe, and
            3. The site grading,
            4. Where Di can be determined using Figure A-4 and Equation A-2:

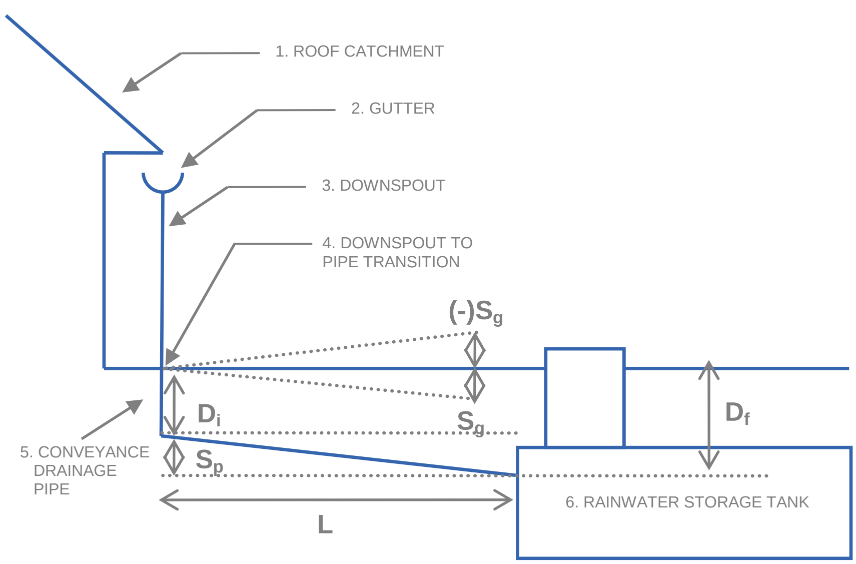

Figure A-4. Pipe conveyance (profile view)

$$\boldsymbol{D_i} = D_f - L_p S_p + L_g S_g$$

Equation A-2

Where:

D_i = Initial pipe burial depth (m)
D_f = Final pipe burial depth (m)
L_p = Length of pipe (m)
L_g = Length of pipe for which there is a grade change (m)
S_p = Pipe slope factor (0.01 recommended)
S_g = Grade slope factor, assumes downward slope

iii. If D_f and/or D_i is less than the frost penetration depth, then there is a risk of rainwater freezing in the conveyance network. In such cases, repeat the above process, while considering the following:
   1. Locate the tank in an area with the lowest elevation at the site,
   2. Minimize the distance between the furthest downspout and the tank (decrease the horizontal travel distance, H),
   3. Increase the burial depth of the tank (ensure that the tank is rated to handle increased burial depth), and/or
   4. Reduce the pipe slope to a minimum of 0.5-1%.

iv. If the conveyance drainage pipe cannot be maintained at or near frost penetration depth, consider insulating pipe (refer to the method below), or alternatively, install heat tracing for use during periods of extreme cold.

3. If burial below the frost penetration depth is not feasible, the pipe should be insulated:
   a. Figure A-5 and Equation A-3 can be used to estimate the width of insulation required:

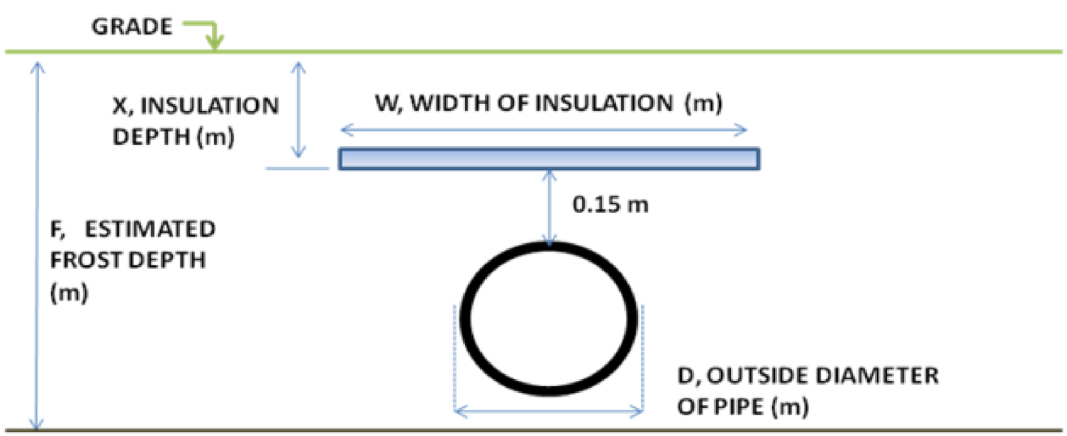

Figure A-5. Frost protection of pipe by horizontal insulation[19]

[19] Adapted from Ontario's Building Code. 2006. Ministry of Municipal Affairs and Housing, Toronto, ON.

$$\boldsymbol{W} = D + [2 \times (F - X)] - 0.3$$

Equation A-3[20]

Where:

W = width of insulation (m)
D = outside diameter of pipe (m)
X = insulation depth (m)
F = estimated frost depth (m)

b. The thickness of the insulation can be estimated using Table A-7:

Table A-7. Thickness of foam insulation given various pipe burial (backfill) depths[21]

Thickness of Foam Insulation (mm)								
		Frost Depth						
Amount of Backfill over the Insulation		**1.1 m**	**1.3 m**	**1.5 m**	**1.7 m**	**1.9 m**	**2.1 m**	**2.3 m**
	≤ 0.6 m	50	65	75	90	100	115	125
	≤ 0.9 m	40	50	65	75	90	100	115
	≤ 1.2 m	25	40	50	65	75	90	100
	≤ 1.5 m		25	40	50	65	75	90
	≤ 1.8 m				40	50	65	75
	≤ 2.1 m					40	50	65

[20] Adapted from Ontario's Building Code. 2006. Ministry of Municipal Affairs and Housing, Toronto, ON.
[21] Adapted from Ontario's Building Code. 2006. Ministry of Municipal Affairs and Housing, Toronto, ON, and Canada Normal Freezing Index in Degree Days, Period 1931-1960. Environment Canada, Ottawa, ON.

Appendix B. Rainwater Storage & Tank Sizing

Note: Some of the fixtures listed in this Appendix may not be permitted by the applicable provincial codes and regulations. Data and examples referencing such fixtures are provided for illustration purposes only.

Rainwater Harvesting Design Tool

1. Rainwater storage tanks can be sized using the Rainwater Harvesting System Design Tool, which can be accessed on-line;
2. Instructions on the use of the Rainwater Harvesting System Design Tool are provided with the Design Tool software package. Refer to these instructions for further details.

Rainwater Storage Tank Sizing Table

1. Rainwater storage tanks can be sized using Table B-3, which was developed using the Rainwater Harvesting System Design Tool. *Note:* Table B-3 *summarizes results from the tool for the City of Edmonton, but these tank sizes should be applicable for much of Alberta. In regions where there is less annual rainfall than Edmonton, tanks with larger storage capacities than those listed in* Table B-3 *are recommended.*
2. Household indoor rainwater demand can be estimated using Table B-1 and the following instructions:
    a. For each fixture to be supplied with rainwater, determine the fixture type and associated water usage by examining the fixture and/or referring to the manufacturer's product literature;
    b. Once the fixture type and water usage have been determined, calculate the daily rainwater usage for the fixture by multiplying the water usage (provided by the manufacturer, or using the average figures provided in Table B-1) by the number of uses per person per day (provided in Table B-1). Multiply the resulting figure by the number of occupants residing within the household;
    c. Sum these values to determine the total indoor rainwater demand (Litres per day);
    d. Sum the total indoor rainwater demand with the total outdoor rainwater demand, where applicable (refer to Table B-2 and the accompanying instructions for assistance on calculating outdoor rainwater usage);

Table B-1. Household indoor fixtures and associated water usage figures/assumptions[22]

Fixtures	Fixture Type	Water Usage	Number of Uses Per Person Per Day	Water Usage Duration
Toilet	Low flush	13.0 Litres/flush	5	-
Toilet	Ultra-low flush	6.0 Litres/flush	5	-
Toilet	Dual flush/HET	4.8 Litres/flush	5	-
Laundry	Top loading	150 Litres/load	0.37	-
Laundry	Front loading	100 Litres/load	0.37	-
Lavatory	Inefficient/old	8.0 Litres/minute	3	0.5 minutes
Lavatory	Standard	5.3 Litres/minute	3	0.5 minutes
Lavatory	High-efficiency	3.2 Litres/minute	3	0.5 minutes
Shower	Inefficient/old	9.5 Litres/minute	0.3	5 minutes
Shower	Standard	8.3 Litres/minute	0.3	5 minutes
Shower	High-efficiency	5.7 Litres/minute	0.3	5 minutes

e. Example:

For a household of five, using rainwater for toilet flushing and laundry:

- The toilets in the home are the ultra-low flush 6.0 Litre per flush type.
- The washing machine is a typical top-loading machine using 150 Litres per load.

Daily rainwater demand (Toilets) = 6.0 Litres/flush × 5 flushes per person per day × 5 persons
Daily rainwater demand (Toilets) = 150 Litres/day

Daily Indoor Rainwater Demand (Total) = 150 Litres/day

3. Household outdoor rainwater demand can be estimated using Table B-2and the following instructions:
   a. For each fixture to be supplied with rainwater, determine the fixture type and associated water usage by examining the fixture and/or referring to the manufacturer's product literature;
   b. Once the fixture type and water usage have been determined, calculate the weekly rainwater usage:
      i. For the garden hose by multiplying the water usage (provided by the manufacturer, or using the average figures provided in Table B-2) by the number of uses per week and multiplying the resulting figure by the water usage duration (provided in Table B-2),
      ii. For the irrigation system by multiplying the water usage (provided by the manufacturer, or using the average figures provided in Table B-2) by the

[22] Adapted from: Vickers, A. 2001. Handbook of Water Use and Conservation. Water Plow Press. Amherst, MA.

irrigated area (in m^2), and multiplying the resulting figure by the number of times the irrigation system is used per week (provided in Table B-2).

c. Convert this weekly rainwater usage to a daily usage by dividing the above figure by 7;

d. Repeat this process for each of the fixtures to be supplied with rainwater, and sum these values to determine the total outdoor rainwater demand (Litres per day);

e. Sum the total outdoor rainwater demand with the total indoor rainwater demand, where applicable (refer to Table B-1 and the accompanying instructions for assistance on calculating indoor rainwater usage);

Table B-2. Household Outdoor Fixtures and Associated Water Usage Figures/Assumptions[23]

Fixtures	Fixture Type	Water Usage	Number of Uses per Week	Water Usage Duration
Garden Hose	Hose with 13 mm [1/2 in.] supply	11 Litres/minute	3	30 minutes
Garden Hose	Hose with 18 mm [3/4 in.] supply	19 Litres/minute	3	30 minutes
Irrigation System	Providing equivalent of25 mm [1 in.] rainfall per use	25 Litres/m^2	3	-
Irrigation System	Providing equivalent of 13 mm [1/2 in.] rainfall per use	12.5 Litres/m^2	3	-
Irrigation System	Providing equivalent of 6 mm [1/4 in.]" rainfall per use	6 Litres/m^2	3	-

f. Example:

For a household using rainwater for both a garden hose and an irrigation system:

- The garden hose has a ½" supply, and is used three times each week, for approx. 30 minutes each time
- The irrigation system provides the equivalent of ¼" rainfall per use, and has an irrigated area of 50 m^2.

Weekly rainwater demand (Garden hose) = 11 Litres/minute × 30 minutes × 3 uses per week
Weekly rainwater demand (Garden hose) = 990 Litres/week

Daily rainwater demand (Garden hose) = 1017 Litres/week ÷ 7 days/week
Daily rainwater demand (Garden hose) = 141 Litres/day

[23] Residential Water Systems: Goulds Pumps Technical Data, Water Products. 2007. ITT Corporation, White Plains, NY.

Weekly rainwater demand (Irrigation System) = 6 Litres/m^2 × 50 m^2 irrigated area × 3 uses per week
Weekly rainwater demand (Irrigation System) = 900 Litres/week

Daily rainwater demand (Irrigation System) = 900 Litres/week ÷ 7 days/week
Daily rainwater demand (Irrigation System) = 129 Litres/day

Daily Outdoor Rainwater Demand (Total) = 141 Litres/day + 129 Litres/day
Daily Outdoor Rainwater Demand (Total) = 270 Litres/day

4. Calculate the daily rainwater demand (Litres per day) by summing the household indoor rainwater demand and the outdoor rainwater demand;
   a. Example:

      Summing indoor & outdoor demand:

      Daily Rainwater Demand (Total) = 150 Litres/day + 270 Litres/day
      Daily Rainwater Demand (Total) = 420 Litres/day

5. Refer to Table B-3 to find the recommended tank size using the daily rainwater demand (Litres per day) and the roof catchment area (m^2);
6. Note: How were Table B-3 recommended storage volumes determined?
   a. For each unique combination of daily rainwater demand and roof catchment area (i.e., for a RWH system with a daily rainwater demand of 50 Litres/day and a roof catchment area of 100 m^2) rainwater storage tanks of increasing storage capacities were modelled using the Rainwater Harvesting Design Tool;
   b. While comparing the multiple tanks, if a tank with a larger storage capacity provided a significant increase in the water savings provided by the RWH system, when compared against a smaller tank, the Design Tool recommended the larger tank.
   c. This process was repeated with increasing storage tank volumes until the water savings increase provided by the larger tank was considered to be insignificant;
   d. The criteria that was used to distinguish between a significant and insignificant was as follows:
      i. If larger tank provides ≥ 2.5% increase in water savings per 1,000 Litres, select larger tank and continue process to examine the water savings of subsequent larger tanks;
      ii. If larger tank provides < 2.5% increase in water savings per 1,000 Litres, do not consider the tank, and recommend the largest storage tank that met the ≥ 2.5% criteria.

Table B-3. Recommended storage tank capacities for catchment areas and rainwater demands for RWH systems located in Edmonton, Alberta

Daily Rainwater Demand (Litres per day)	Optimum Rainwater Storage Tank Cistern Capacity (L)																		
	Roof Catchment Area (m^2)																		
	50	100	150	200	250	300	350	400	450	500	600	700	800	900	1,000	1,500	2,000	2,500	3,000
50	**2,000**	**2,000**	**2,000**	**2,000**	**2,000**	**2,000**	**2,000**	**2,000**	**2,000**	**2,000**	**2,000**	**2,000**	**2,000**	**2,000**	**5,000**	**5,000**	**5,000**	**5,000**	5,000
100	**2,000**	**4,000**	**4,000**	**4,000**	**4,000**	**4,000**	**4,000**	**4,000**	**4,000**	**4,000**	**4,000**	**4,000**	**4,000**	**4,000**	**5,000**	**5,000**	**5,000**	**5,000**	5,000
150	**2,000**	**4,000**	**4,000**	**4,000**	**4,000**	**5,000**	**5,000**	**5,000**	**5,000**	**5,000**	**5,000**	**5,000**	**5,000**	**5,000**	**5,000**	**5,000**	**5,000**	**5,000**	5,000
200	**2,000**	**4,000**	**4,000**	**4,000**	**4,000**	**5,000**	**5,000**	**5,000**	**7,500**	**7,500**	**7,500**	**7,500**	**7,500**	**7,500**	**7,500**	**7,500**	**7,500**	**7,500**	7,500
250	-	**4,000**	**4,000**	**4,000**	**4,000**	**5,000**	**5,000**	**5,000**	**7,500**	**7,500**	**7,500**	**7,500**	**7,500**	**7,500**	**7,500**	**7,500**	**7,500**	**7,500**	7,500
300	-	**4,000**	**4,000**	**4,000**	**4,000**	**5,000**	**5,000**	**5,000**	**7,500**	**7,500**	**7,500**	**10,000**	**10,000**	**10,000**	**10,000**	**10,000**	**10,000**	**10,000**	10,000
350	-	**4,000**	**4,000**	**4,000**	**4,000**	**5,000**	**5,000**	**5,000**	**7,500**	**7,500**	**7,500**	**10,000**	**10,000**	**10,000**	**10,000**	**10,000**	**10,000**	**10,000**	10,000
400	-	**4,000**	**4,000**	**4,000**	**4,000**	**5,000**	**5,000**	**5,000**	**7,500**	**7,500**	**7,500**	**10,000**	**10,000**	**10,000**	**10,000**	**10,000**	**10,000**	**10,000**	10,000
450	-	**4,000**	**4,000**	**4,000**	**4,000**	**5,000**	**5,000**	**5,000**	**7,500**	**7,500**	**7,500**	**10,000**	**10,000**	**10,000**	**10,000**	**10,000**	**10,000**	**10,000**	10,000
500	-	-	**4,000**	**4,000**	**4,000**	**5,000**	**5,000**	**5,000**	**7,500**	**7,500**	**7,500**	**10,000**	**10,000**	**10,000**	**10,000**	**15,000**	**15,000**	**15,000**	15,000
600	-	-	**4,000**	**4,000**	**4,000**	**5,000**	**5,000**	**5,000**	**7,500**	**7,500**	**7,500**	**10,000**	**10,000**	**10,000**	**10,000**	**15,000**	**15,000**	**15,000**	15,000
700	-	-	**4,000**	**4,000**	**4,000**	**5,000**	**5,000**	**5,000**	**7,500**	**7,500**	**7,500**	**10,000**	**10,000**	**10,000**	**10,000**	**15,000**	**15,000**	**15,000**	15,000
800	-	-	**4,000**	**4,000**	**4,000**	**5,000**	**5,000**	**5,000**	**7,500**	**7,500**	**7,500**	**10,000**	**10,000**	**10,000**	**10,000**	**15,000**	**15,000**	**15,000**	15,000
900	-	-	**4,000**	**4,000**	**4,000**	**5,000**	**5,000**	**5,000**	**7,500**	**7,500**	**7,500**	**10,000**	**10,000**	**10,000**	**10,000**	**15,000**	**15,000**	**15,000**	15,000
1,000	-	-	**4,000**	**4,000**	**4,000**	**5,000**	**5,000**	**5,000**	**7,500**	**7,500**	**7,500**	**10,000**	**10,000**	**10,000**	**10,000**	**15,000**	**15,000**	**15,000**	15,000
1,500	-	-	-	-	**4,000**	**5,000**	**5,000**	**5,000**	**7,500**	**7,500**	**7,500**	**10,000**	**10,000**	**10,000**	**10,000**	**15,000**	**15,000**	**15,000**	15,000
2,000	-	-	-	-	-	**5,000**	**5,000**	**5,000**	**7,500**	**7,500**	**7,500**	**10,000**	**10,000**	**10,000**	**10,000**	**15,000**	**15,000**	**15,000**	15,000
2,500	-	-	-	-	-	-	-	**5,000**	**7,500**	**7,500**	**7,500**	**10,000**	**10,000**	**10,000**	**10,000**	**15,000**	**15,000**	**15,000**	15,000
3,000	-	-	-	-	-	-	-	-	-	**7,500**	**7,500**	**10,000**	**10,000**	**10,000**	**10,000**	**15,000**	**15,000**	**15,000**	15,000

Recommended rainwater storage tank capacities generated using the Rainwater Harvesting System Design Tool assuming:

1. Historical rainfall for the City of Edmonton, from 1961-2005 (median annual rainfall: 346 mm);
2. Optimum rainwater storage tank capacity values include an assumption of a 20% unused volume (typically referred to as 'dead space').

Appendix C. Pump and Pressurized Distribution System

Note: Some of the fixtures listed in this Appendix may not be permitted by the applicable provincial codes and regulations. Data and examples referencing such fixtures are provided for illustration purposes only.

Calculation of Required Pump Capacity

1. For estimation purposes only, the maximum peak demand (minimum recommended pump flow rate) can be calculated using Table C-1, Table C-2, and methods below. *Note that this method is an industry standard method – be sure to consult local building authorities to ensure that the below flow rates are permitted for the fixtures served by the rainwater harvesting system.*

Table C-1. Minimum recommended water flow rate for various indoor fixtures[24]

Indoor Fixtures	Minimum Flow Rate (Per Fixture)
Shower or Bathtub	19 LPM [5 GPM]
Lavatory	1 LPM [0.3 GPM]
Toilet	2.7 LPM [0.7 GPM]
Kitchen Sink	1.6 LPM [0.4 GPM]
Washing Machine	19 LPM [5 GPM]
Dishwasher	7.6 LPM [2 GPM]

[24] Adapted from Residential Water Systems: Goulds Pumps Technical Data, Water Products. 2007. ITT Corporation, White Plains, NY. (flow rates from Jet and Submersible Pump Selection for Private Residences table, total usage column values ÷ 7)

Table C-2. Minimum recommended water flow rate for various outdoor fixtures[25]

Outdoor Fixtures	Minimum Flow Rate (Per Fixture)
Garden hose with 13 mm [1/2 in.] supply	11 LPM [3 GPM]
Garden hose with 18 mm [3/4 in.] supply	19 LPM [6 GPM]
Irrigation system	Varies (Consult supplier/ contractor)

2. Example:

Using Table C-1, if a given pump and pressure system must provide rainwater to three toilets, a washing machine and hose bib the maximum peak demand can be determined as follows:

Table C-3. Example calculation – sizing maximum peak demand

Indoor Fixtures	Number of Fixtures	Minimum Flow Rate (Per Fixture)	Total Flow Rate
Toilet	3	2.7 LPM	8.1 LPM
Washing machine	1	19 LPM	19 LPM
Hose watering (1/2 in. supply)	1	11 LPM	11 LPM
Maximum peak demand			**38 LPM**

As shown in Table C-3, the total water usage is determined by multiplying the number of fixtures by the minimum flow rate for each fixture, and is summed for all types of fixtures to estimate the maximum peak demand.

For the above application, a pump providing a minimum flow rate of 38 LPM [10 GPM] pump is recommended.

[25] Adapted from Residential Water Systems: Goulds Pumps Technical Data, Water Products. 2007. ITT Corporation, White Plains, NY. (flow rates from Yard Fixtures table)

Calculation of Required Pressure from Pump (Pump Head)

1. The pump head can be calculated using the following equations:
   a. Pump Head (m, or ft) = Required System Pressure + Total Dynamic Head

      Where:

      Required System Pressure is the operating pressure required for the rainwater fixtures (275-415 kPa [~40-60 psi] for typical residential applications). Pressure can be converted from kPa or psi to m or ft using Table C-4:

Table C-4. Conversion factors for 'kPa' and 'psi'

	Pressure (kPa)	Pressure (psi)
Conversion to Metres (m)	Height (m) = ____ kPa x 0.10	Height (m) = ____ psi x 0.70
Conversion to Feet (ft)	Height (ft) = ____ kPa x 0.33	Height (ft) = ____ psi x 2.31

   b. Total Dynamic Head (m, or ft) = Static Lift + Static Height + Friction Loss

      Where:

      Static Lift is the height from the water level to the pump (applicable only for jet pumps),
      Static Height is the height from the pump to the furthest fixture, and
      Friction Loss can be calculated using the method provided below.

Calculation of Friction Loss

1. To calculate the Friction Loss component of the Total Dynamic Head:
    a. Calculate the friction head losses that occur due to the flow rate and pipe sizes using Table C-5 (table values assume a SCH40 PVC pipe or similar material such as PE-polyethylene or PP-polypropylene is utilized):

Table C-5. Friction head losses for SCH40 PCV pipe at various flow rates[26]

Flow Rate, Q (LPM)	F_{100}, Friction Head (m / 100 m pipe) Pipe Diameter					
	13 mm [½ in.]	18 mm [¾ in.]	25 mm [1 in.]	32 mm [1 ¼ in.]	38 mm [1 ½ in.]	50 mm [2 in.]
8	4.8	1.2	0.38	0.1		
19	25.8	6.3	1.9	0.5	0.2	
30	63.7	15.2	4.6	1.2	0.6	0.2
38	97.5	26	6.9	1.8	0.8	0.3
57		49.7	14.6	3.8	1.7	0.5
76		86.9	25.1	6.4	2.9	0.9
113				13.6	6.3	1.8

    b. Example:

Using Table C-5, for a pump generating a flow rate of 38 LPM [10 GPM], with a rainwater service pipe diameter of 32 mm [1 ¼ in.] and a rainwater supply pipe diameter of 18 mm [¾ in.]:

$F_{100\text{-}SE}$, Friction head (m /100 m pipe) = 1.8 m/ 100 m pipe-service pipe

$F_{100\text{-}SU}$, Friction head (m /100 m pipe) = 26 m / 100 m of pipe-supply pipe

[26] Adapted from Residential Water Systems: Goulds Pumps Technical Data, Water Products. 2007. ITT Corporation, White Plains, NY.

c. Calculate the friction head losses that occur due to the type of pipe fitting and pipe size using Table C-6 (table values assume a SCH40 PVC pipe or similar material such as PE-polyethylene or PP-polypropylene is utilized).

Table C-6. Equivalent length of pipe for different fittings[27]

Fitting	Equivalent Length of Pipe (m) Pipe Diameter						
	13 mm [½ in.]	18 mm [¾ in.]	25 mm [1 in.]	32 mm [1 ¼ in.]	38 mm [1 ½ in.]	50 mm [2 in.]	75 mm [3 in.]
90° Elbow	0.5	0.6	0.8	1.1	1.3	1.7	2.4
45° Elbow	0.2	0.3	0.4	0.5	0.6	0.8	1.2
Gate Valve (shut-off valve) (Open)	0.1	0.2	0.2	0.2	0.3	0.4	0.5
Tee Flow – Run	0.3	0.6	0.6	0.9	0.9	1.2	1.8
Tee Flow - Branch	1.0	1.4	1.7	2.3	2.7	3.7	5.2
In Line Check Valve (Spring) or Foot Valve	1.2	1.8	2.4	3.7	4.3	5.8	9.8
90° Elbow	0.5	0.6	0.8	1.1	1.3	1.7	2.4

d. Example:

Using Table C-6, for a pressure system with three 32 mm [1 ¼ in.] 90° elbows on the rainwater service piping, and five 18 mm [¾ in.] 90° elbows on the rainwater supply piping:

$L_{F\text{-}SE}$, Equivalent Length of Pipe (m) = 3 x 1.1
$L_{F\text{-}SE}$, Equivalent Length of Pipe (m) = 3.3 m-service pipe

$L_{F\text{-}SU}$, Equivalent Length of Pipe (m) = 5 x 0.6
$L_{F\text{-}SU}$, Equivalent Length of Pipe (m) = 3.0 m-supply pipe

e. To calculate the total friction head losses, Equation C-1 should be used:

$$\boldsymbol{Friction\ Loss} = \left[(L_{P-SE} + L_{F-SE}) \times \frac{F_{100-SE}}{100m\ pipe}\right] + \left[(L_{P-SU} + L_{F-SU}) \times \frac{F_{100-SU}}{100m\ pipe}\right]$$

Equation C-1

[27] Adapted from Residential Water Systems: Goulds Pumps Technical Data, Water Products. 2007. ITT Corporation, White Plains, NY.

Where:

Friction Loss = Combined friction losses (m) for the service piping (SE) and supply piping (SU)
L_P = Linear length of pipe (m)
L_F = Equivalent length of the pipe fittings (m)
F_{100} = Friction loss per 100 m of pipe

f. Example:

Using the above equation, the losses for a pump and pressure system using the above pipe diameters and number of fittings, where the length of the rainwater service piping was 15 m and the rainwater supply piping was 10 m:

$$\boldsymbol{Friction\ Loss} = \left[(15\ m + 3.3\ m)\ \times \frac{1.8\ m}{100m\ pipe}\right] + \left[(10\ m + 3\ m)\ \times \frac{26\ m}{100m\ pipe}\right]$$

$$\boldsymbol{Friction\ Loss} = [0.33\ \text{m}]\ +\ [3.38\ \text{m}]$$
$$\boldsymbol{Friction\ Loss} = 3.7\ \text{m}\ [12.2\ \text{ft.}]$$

For the pump and pressure system described above, the friction loss is equivalent to 3.7 m of pipe, which can be used to calculate the Total Dynamic Head.

Calculation of Pressure Tank Size

1. To size a pressure tank that is compatible with a constant speed pump:
   a. Use the following equation to calculate the required capacity for the pressure tank:

$$\boldsymbol{Tank\ Size\ (L)} = 3.78\ \times \left(\frac{Pump\ flow\ rate\ (GPM) \times Pump\ run\ time\ (min)}{Drawdown\ factor}\right)$$

Equation C-2

Where:

Pump flow rate (capacity) was determined above,
Pump run time is provided by the pump manufacturer/supplier (typically, 1-2 minutes), and
The drawdown factor can be determined using Table C-7:

Table C-7. Drawdown factors for various cut-in/cut-out pressures[28]

System Pressure (Cut-in/Cut-out Pressure)	Drawdown Factor
138/276 kPa [20/40 psi]	0.37
276/414 kPa [40/60 psi]	0.27
414/552 kPa [60/80 psi]	0.21
552/689 kPa [80/100 psi]	0.17

Calculation of Pipe Size

1. To determine the required pipe size diameter for the rainwater service piping and supply piping, the following steps can be used for estimation purposes:
   a. For the service piping:
      i. The diameter of the rainwater service pipe can be sized using the equation below (the equation assumes PVC or similar material such as PE-polyethylene or PP-polypropylene is utilized):

$$\boldsymbol{Pipe\ Diameter}\ (\mathbf{mm}) = 25.4 \times \left(\frac{0.098 \times \frac{Q}{3.78}^{1.85}}{F_{100-SE}}\right)^{\frac{1}{4.87}}$$

Equation C-3[29]

Where:

Q = the pump flow rate (LPM)
F_{100} = the friction loss per 100 m of pipe (see following steps for details)

      ii. Before this equation can be solved, however, the maximum permitted head loss (F100-SE) must be set. A general rule of thumb is that this loss not exceed 5 m / 100 m pipe [5 ft / 100 ft pipe][30] , however the pump manufacturer/supplier should be contacted to confirm that these head losses will not impair pump performance or cause a loss of prime,

[28] Adapted from Residential Water Systems: Goulds Pumps Technical Data, Water Products. 2007. ITT Corporation, White Plains, NY.
[29] Adapted from Hazen-Williams Equation - Calculating Friction Head Loss in Water Pipes. 2005. The Engineering ToolBox.
[30] Planning for an Individual Water System. Fourth Edition Revised. 1982. Turner, H.J., Athens, GA.

iii. Example:

Assuming that $F_{100\text{-}SE}$ = 5 m / 100 m of pipe, the pipe diameter can be calculated as follows for a 38 LPM [10 GPM] pump:

$$\textbf{\textit{Pipe Diameter}}\ (\mathbf{mm}) = 25.4\ \times \left(\frac{0.098\ \times \left(\frac{38}{3.78}\right)^{1.85}}{5}\right)^{\frac{1}{4.87}}$$

$$\textbf{\textit{Pipe Diameter}}\ (\mathbf{mm}) = 27.2$$

$$\textbf{\textit{Pipe Diameter}}\ (\mathbf{mm}) \cong 32\ \text{mm}\ \left[1\ {}^{1}/_{4}\ in.\right]$$

b. For the supply piping:
   i. Rainwater supply pipe must be sized in accordance with applicable provincial codes and regulations. The following information is provided for estimation purposes only,
   ii. To size the rainwater supply pipe, refer to Table C-8 and instructions below:

Table C-8. Supply pipe sizing for various fixtures[31]

Fixture	Minimum Size of Supply Pipe	Hydraulic Load (fixture units)
Toilet	10 mm [⅜ in.]	3
Urinal	13 mm [½ in.]	3
Hose bib	13 mm [½ in.]	2
Washing machine	13 mm [½ in.]	2
Lavatory	10 mm [⅜ in.]	1
Bathtub (with or without shower)	13 mm [½ in.]	2

   iii. In Table C-8, the minimum diameter of pipe that can be used to supply an individual residential plumbing fixture is listed in the second column (i.e., for toilets, the minimum size of supply pipe permitted is 10 mm [⅜ in.]),
   iv. The values in the third column, hydraulic load (fixture units), are used to determine the pipe diameter of the piping immediately following the pressure tank/control unit. This represents the diameter of the main branch from which smaller supply pipes will be run to individual fixtures,
   v. The hydraulic load of the pump and pressure system is calculated by summing up the number of fixture units based upon the types and number of fixtures connected to the system,

[31] Adapted from National Plumbing Code of Canada. 2005. National Research Council of Canada, Ottawa, ON.

vi. Example:

If three toilets and one washing machine are connected to the system, the hydraulic load can be calculated as follows:

Hydraulic load (fixture units) = (3 x 3) + (1 x 2)

Hydraulic load (fixture units) = 11 fixture units

vii. Once the number of fixture units have been determined, the required size of rainwater supply pipe can be determined using Table C-9:

Table C-9. Maximum allowable pipe lengths[32]

Pipe Diameter	Maximum Allowable Length (m) 12	18	24	30
	Number of Fixture Units Served			
13 mm [½ in.]	6	5	4	3
18 mm [¾ in.]	18	16	14	12
25 mm [1 in.]	36	31	27	25
32 mm [1 ¼ in.]	54	47	42	38
38 mm [1 ½ in.]	151	124	105	91

viii. Example:

Referring to Table C-9, if the total length of the supply pipe is 17 m, and the hydraulic load is equal to 11 fixture units:

Pipe diameter = 18 mm [¾ in.]

Note: With the example above, ¾ in. pipe must be used since 17 m > 12 m, so the 18 m column must be referenced, following which 11 fixture units > 5 fixture units (making ½ in pipe insufficient), therefore ¾ in. pipe must be used, as 11 fixture units < 16 fixture units.

[32] Adapted from National Plumbing Code of Canada. 2005. National Research Council of Canada, Ottawa, ON.

Appendix D. Overflow Provisions & Stormwater Management

Utilizing a Rainwater Storage Tank for Retention & Detention for Stormwater Management Purposes

1. To design a rainwater harvesting system for the purpose of extended detention and controlled release of stormwater, the following schematic (Figure D-1) and guidelines are provided for estimation purposes only:

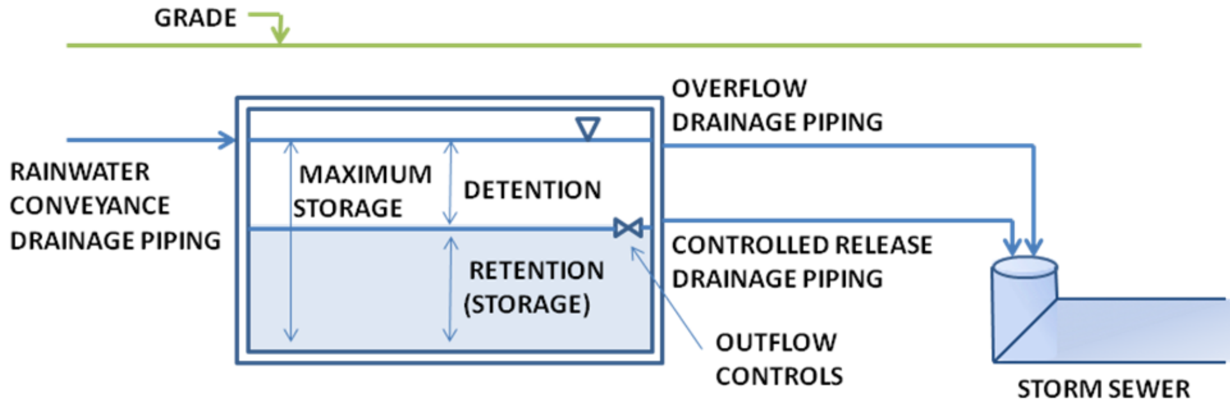

Figure D-1. Schematic of RWH system with outflow controls and controlled release drainage piping for stormwater management. ('DETENTION' is the volume of runoff to be slowly released to storm sewer. The remaining volume 'RETENTION' is used to supply rainwater to permitted fixtures)

   a. To size the retention (storage) volume:
      i. Refer to *Appendix B* for guidelines regarding the sizing of rainwater storage tanks. The storage tank volume determined using the methods provided in *Appendix B* shall be the retention volume of the rainwater tank.
   b. To size the detention volume:
      i. *Note: while a rainwater tank can be used to provide extended detention for stormwater management purposes, the required storage volumes may be very large for large roof areas,*
      ii. Contact the local conservation authority and/or municipality regarding the size of rainfall event or volume of stormwater to be detained in the tank for the particular site;

iii. Example:

If a municipality requires that 5 mm of rainfall must be detained, then for a roof with a 200 m^2 catchment area:

$$\boldsymbol{Detention\ Volume\ (L)} = Rainfall\ event\ (mm) \times Area\ (m^2\ )$$

Equation D-1

$$\boldsymbol{Detention\ Volume\ (L)} = 5\ mm\ \times 200\ m^2$$
$$\boldsymbol{Detention\ Volume\ (L) = 1000\ L}$$

c. Given the detention volume, the maximum storage depth can be calculated by:

$$H = \frac{V}{w\ \times l}$$

Equation D-2[33]

Where:

H = Maximum storage depth, measured from the bottom of the overflow drainage pipe to the centreline of the drawdown pipe (m)
V = Stormwater detention volume (m^3)
w = Width of the rainwater storage tank (m)
l = Length of the rainwater storage tank (m)

d. Next, the rate of discharge from the controlled release pipe can be determined as follows:

$$Q = Q_{AVG}\ \times F$$

Equation D-3[34]

Where:

Q = Peak discharge rate (m^3/s)
Q_{AVG} = Average discharge rate, (discharge volume/drawdown time) (m^3/s)
F = Peaking factor (typically 1.5)

e. Finally, to size the diameter of the controlled release pipe:

$$D^2 = \frac{4\ Q}{C_d\ \pi\ \sqrt{2gH}}$$

Equation D-4[35]

[33] Adapted from Low Impact Development Stormwater Management Manual (Draft).2008. Toronto and Region Conservation Authority, Toronto, ON.
[34] Low Impact Development Stormwater Management Manual (Draft).2008. Toronto and Region Conservation Authority, Toronto, ON.

Where:

D= Required controlled release pipe diameter (m)
Q= Peak discharge rate (m^3/s)
C_d = Coefficient depending on the type of orifice (available in engineering texts or manuals)
g = Acceleration due to gravity (9.8 m/s^2)
H = Maximum storage depth, measured from the bottom of the overflow drainage pipe to the centreline of the drawdown pipe (m)

f. Example:

For a rainwater harvesting system with the characteristics listed in Table D-1, a rainwater harvesting system for detention and controlled release can be sized as follows:

Table D-1. RWH system characteristics (example)

Detail	Value
Storage tank volume	18 m^3
Maximum stormwater detention volume	9 m^3
Storage tank dimensions (l x w x h)	6.2m x 2.6m x 1.3m

$$H = \frac{V}{w \times l}$$

$$H = \frac{9 \text{ m}^3}{6.2 \text{ m} \times 2.6 \text{ m}}$$
$$H = 0.56 \text{ m}$$

$$\boldsymbol{H \approx 0.6 \text{ m}}$$

Given this height, the centerline (middle) of the controlled release pipe would need to be installed at a height 0. 6 m below the bottom of the overflow drainage pipe.

35 Adapted from Stormwater Management Planning and Design Manual. 2003. Ontario Ministry of the Environment, Toronto, ON.

The peak discharge from the rainwater storage tank, over a 24 hour period would be:

$$Q_{AVG} = \frac{9 \text{ m}^3}{24\ hr \times 60\ \frac{min}{hr} \times 60\ \frac{s}{min}}$$

$$Q_{AVG} = 0.000104\ ^{\text{m}^3}/_{\text{s}}$$

$$Q = Q_{AVG} \times F$$
$$Q = 0.000104\ \frac{m^3}{s} \times 1$$
$$\boldsymbol{Q = 0.000156\ ^{\mathbf{m}^3}/_{\mathbf{s}}}$$

Assuming the depth in the cistern is 0.56 m when the full 9 m^3 is being stored, the required pipe size would be:

$$D^2 = \frac{4\ Q}{C_d\ \pi\ \sqrt{2gH}}$$

$$\text{D} = \sqrt{\frac{4 \times 0.000156}{0.62\ \pi\ \sqrt{2 \times 9.8 \times 0.56}}}$$

$$\text{D} = 0.0098 \text{ m}$$
$$\mathbf{D\ \approx 10\ mm}$$

Thus, from these calculations, a 10 mm diameter pipe is required, however, in practice, such a small orifice would not be used as it would be prone to clogging, or to freezing during the winter. A minimum orifice size recommended for controlled release pipes is 75 mm[36]. Consult the local conservation authority and/or municipality regarding the minimum controlled release pipe diameter sizing.

[36] Low Impact Development Stormwater Management Manual (Draft).2008. Toronto and Region Conservation Authority, Toronto, ON. 75 mm is the minimum orifice size required for controlled release pipes in stormwater retention ponds located in the City of Toronto.

Design & Sizing of Soakaway Pits

Soakaway pits are comprised of an excavated space filled with a non-porous material, surrounded by an outer filter fabric. A basic infiltration trench, be suitable for most RWH systems, is illustrated below in Figure D-2.

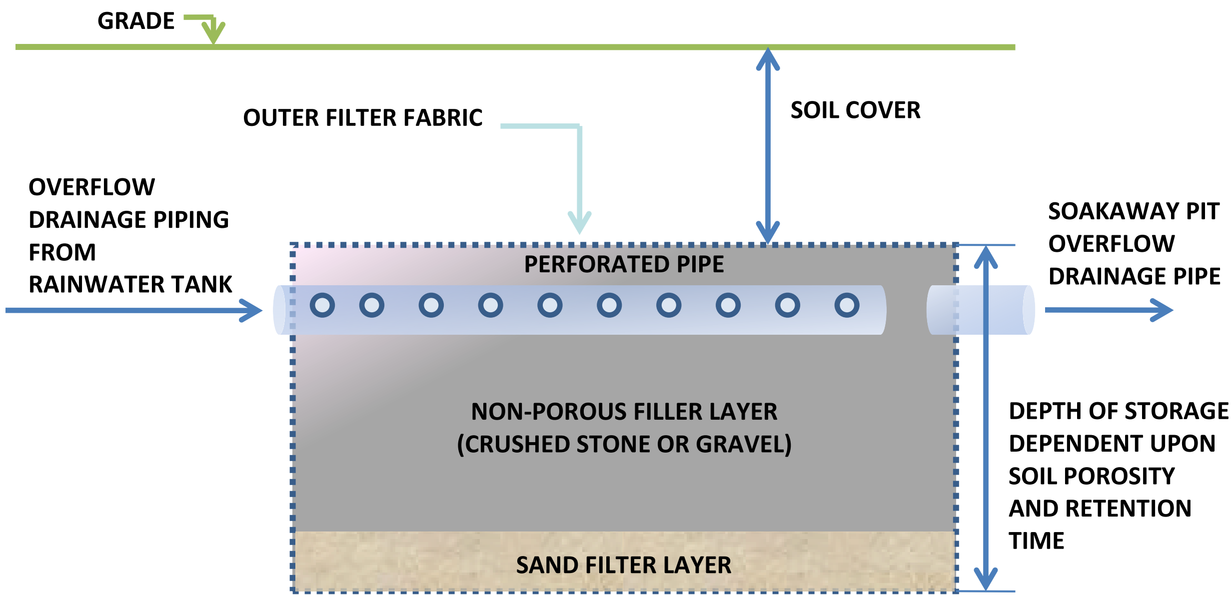

Figure D-2. Sketch of a typical soakaway pit (cross-section view)[37]

The materials required for a soakaway pit include:

1. **Storage media** – crushed stone of a uniform size, used to provide a non-porous structure for the pit.
2. **Outer fabric** – non-woven filter fabric (polypropylene geotextile), used to protect the storage media from becoming clogged by the surrounding soils.
3. **Distribution pipes** – perforated drainage pipe used to distribute rainwater uniformly throughout the entire pit/trench.
4. **Filter layer** - fine sand placed on the outer fabric on the bottom of the trench to filter impurities prior to infiltration.

[37] Adapted from Stormwater Management Planning and Design Manual. 2003. Ontario Ministry of the Environment, Toronto, ON.

1. General design considerations[38]:
    a. The soakaway pit should be located at least 4 m [13 ft.] away from a building foundation or other buried structure, and 1.5 m [5 ft.] from buried water or utility lines;
    b. The length of the pit (parallel to the overflow drainage pipe) should be maximized compared to the width;
    c. The maximum height of the pit/trench should be 1.5 m [5 ft.];
    d. The soakaway pit should be buried sufficiently to protect it from freezing.
2. To size a soakaway pit or infiltration trench, the following guidelines are provided for estimation purposes only[39] :
    a. The depth of the soakaway pit can be calculated using Equation D-5 (further details below):

    $$d = \frac{P \times T}{1{,}000}$$

    Equation D-5

    Where:

    d = Maximum allowable depth of the soakaway pit (m)
    P = Percolation rate (mm/hour)
    T = Drawdown time (hour)

    b. Given the storage depth, the size (area) of the soakaway pit can then be calculated using Equation D-6:

    $$A = \frac{V}{d \times n}$$

    Equation D-6

    Where:

    A = Surface area of soakaway pit (m^2)
    V = Runoff volume to be infiltrated (m^3)
    d = Maximum allowable depth of the soakaway pit (m)
    n = Porosity of storage media (0.4 for clear stone)

    c. When performing Equation D-5 and Equation D-6, the following sizing guidelines are recommended:

[38] Adapted from Stormwater Management Planning and Design Manual. 2003. Ontario Ministry of the Environment, Toronto, ON, and Low Impact Development Stormwater Management Manual (Draft).2008. Toronto and Region Conservation Authority, Toronto, ON.
[39] Adapted from Stormwater Management Planning and Design Manual. 2003. Ontario Ministry of the Environment, Toronto, ON.

i. Soakaway pits can only be used in areas where soils have a percolation rate ≥ 15 mm/hr. Refer to Table D-2 for approximate percolation rates for soils. *Note: to ensure that soils have the necessary infiltration capacity, soils may need to be tested,*

Table D-2. Minimum soil percolation rates[40]

Soil Type	Percolation Rate "P" (mm/hr)
Sand	210
Loamy sand	60
Sandy loam	25
Loam	15

ii. A conservative drawdown time of 24 hr (T = 24 hr) should be chosen when calculating the depth of the soakaway pit/infiltration trench,

iii. The maximum depth (d) of the soakaway pit should be no more than 1.5 m to maximize the infiltration capacity of the pit/trench. If the calculated depth is > 1.5, use 1.5,

iv. The surface area of the trench should be configured in a 4:1 ratio for length to width to ensure the full bottom area of the trench is being used for infiltration,

v. A maximum storage volume equal to the runoff from a 4 hour - 15 mm/h storm is recommended. i.e.,

$$V = \frac{Catchment\ Area\ (m^2) \times 15\ \frac{mm}{hr} \times 4\ hr}{1{,}000\ \frac{mm}{m}}$$

Equation D-7

[40] Adapted from Stormwater Management Planning and Design Manual. 2003. Ontario Ministry of the Environment, Toronto, ON.

d. Example:

For a rainwater harvesting system with the characteristics listed in Table D-3, a soakaway pit can be sized as follows:

Table D-3. RWH system characteristics (example)

Detail	Value
Catchment area (A)	150 m^2
Soil percolation rate (P)	60 mm/hr
Storage media porosity (d)	0.4 clear stone

$$d = \frac{P \times T}{1{,}000}$$

$$d = \frac{60\frac{mm}{h} \times 24h}{1{,}000}$$

$$d = 1.44\,m$$

Given the depth of the soakaway pit, the size (area) of the pit/trench can be calculated by:

$$V = \frac{Catchment\ Area\ (m^2) \times 15\ \frac{mm}{hr} \times 4\ hr}{1{,}000\ \frac{mm}{m}}$$

$$V = \frac{150\ \mathrm{m}^2 \times 15\ \frac{mm}{hr} \times 4\ hr}{1{,}000\ \frac{mm}{m}}$$

$$\boldsymbol{V = 9\ \mathrm{m}^3}$$

$$A = \frac{V}{d \times n}$$

$$A = \frac{9\ m^3}{1.44\ \mathrm{m} \times 0.4}$$

$$\boldsymbol{A = 15.6\ m^2}$$

Given this example, to infiltrate the rainwater on-site given the design criteria of the rainwater harvesting system and the surrounding soils, the soakaway pit would need to be 1.4 m deep, with an area of 16 m^2.

3. The soakaway pit must be buried at a sufficient depth to protect it from frost. Figure D-3 indicates the required soil cover, based on soil type and depth of soakaway pit.

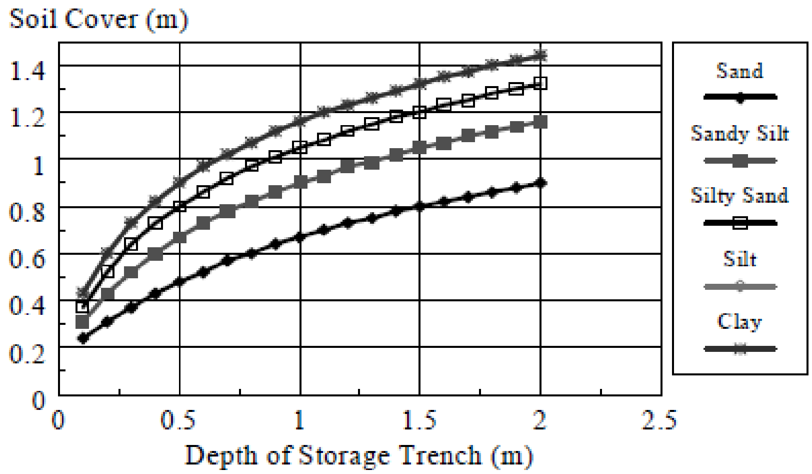

Figure D-3. Soil cover for soakaway pits, based on frost heave[41]

Assessment of Site Soil Infiltration Loading Rate (Percolation Rate)

1. To assist in determining the feasibility and design aspects of utilizing a soakaway pit as an overflow discharge location, soil conditions, including the soil percolation rate, must be determined:
   a. Refer to the Alberta Private Sewage Systems Standard of Practice 2009 for complete guidelines and prescriptive requirements for the performance of a site evaluation and soil profile. The following guidelines are provided for guidance purposes only[42]:
   b. A sufficient number of suitably located soil profiles in the area of the soakaway pit shall be examined and described to adequately determine the variability of the soils on the proposed soakaway pit site:
      i. A minimum of two test pit excavations shall be investigated at the proposed location for the soakaway pit site, using excavated soil pits and intact cores of soil to assess the infiltration capacity of the soil,
      ii. The soil profiles shall be investigated to a minimum depth of 1.8 m [6 ft.] below grade,
      iii. Completing an investigation to a depth that achieves the objectives of the site evaluation and in no case shall the depth be less than 300 mm [12 in.] deeper than the vertical separation distance required below the proposed soakaway pit site.

[41] Stormwater Management Planning and Design Manual. 2003. Ontario Ministry of the Environment, Toronto, ON.
[42] Adapted from Alberta Private Sewage Systems Standard of Practice 2009. Alberta Municipal Affairs, Edmonton, AB.

c. The characteristics of each soil profile investigated shall be described using Canadian System of Soil Classification nomenclature and include the following in the soil profile description[43]:
   i. Horizons: the distance from ground surface to the top and bottom of each horizon observed shall be measured and the distinctness and topography of the horizon boundaries described,
   ii. Colour: for each horizon identified, the matrix color and the quantity, size, contrast, and color of any redoximorphic features present shall be described,
   iii. Texture:
      1. For each horizon identified, the texture class including any appropriate texture modifier shall be reflected in the evaluation report, and
      2. A soil sample of the most restricting layer affecting the design shall be collected and analyzed at a laboratory using a recognized grain or particle size analysis method to determine the texture classification of the sample,
      3. *Note: Where a sand fraction modifier such as coarse, medium, fine, or very fine sand is part of the soil texture classification description the laboratory analysis must include the determination of the sand fraction size distribution*.
   iv. Structure: for each horizon identified, the grade of soil structure observed and the size and type of grades, 0-3 shall be described,
   v. Consistence: for each structure observed in the profile the consistence of the soil peds shall be described,
   vi. Compaction: any zones of compaction in the soil profile shall be described to estimate its affect on water movement, root penetration and aeration,
   vii. Saturated zones: for each soil profile described, the depth to any water or the depth to the estimated seasonally high zone of saturated soil based on redoximorphic or other appropriate features shall be measured,
   viii. Bedrock and near impermeable soil layers: depth to bedrock and near impermeable soil layers observed shall be measured from the ground surface, and
   ix. Flow restricting horizons: for each soil profile described, any horizon that is expected to significantly restrict downward water flow shall be identified and measured to determine its depth below ground surface (Note: such horizons may be discerned by evidence of episaturation above the horizon).
d. The infiltration loading rates (percolation rates) suitable for the soil profile identified at the site, as characterized by the texture and structure of the soil shall be determined using Table D-4 and Figure D-4.

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[43] For further details refer to the Field Book for Describing and Sampling Soils or the Soil Survey Manual available on the web at: http://sis.agr.gc.ca/cansis/intro.html or as included in the Alberta Private Sewage Soils Description Manual.

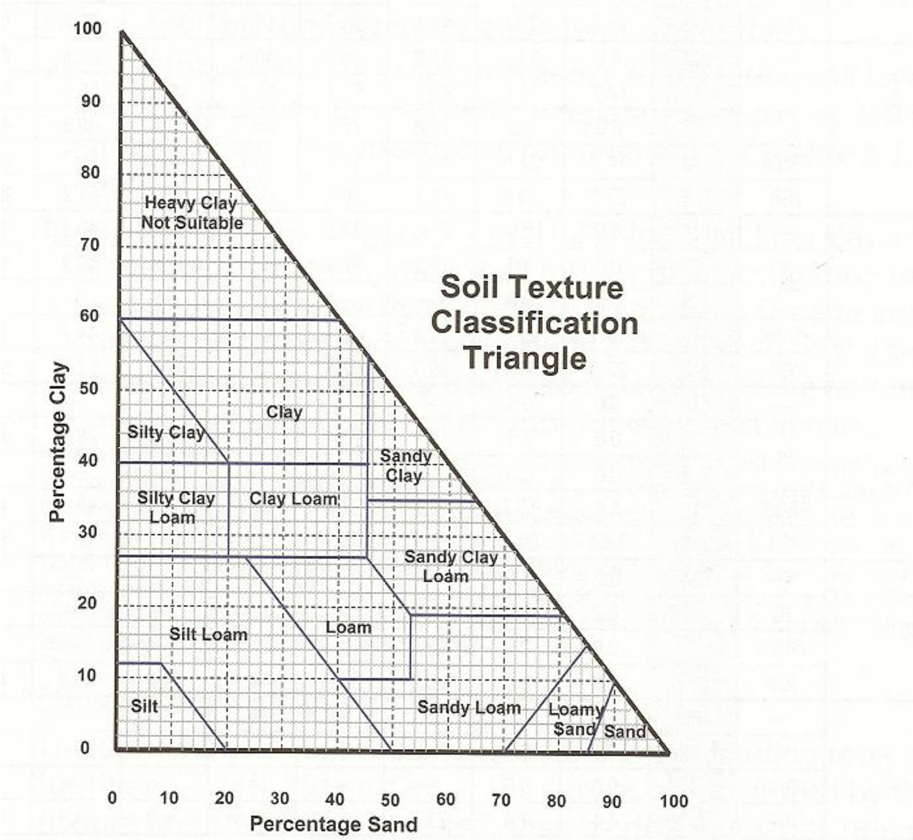
e. The percolation rate utilized when sizing the soakaway pit shall not exceed the amount set out in Table D-4 based on the soil characteristics identified by the site evaluation.

Table D-4. Infiltration loading rates for rainwater[44]

Soil characteristics			Infiltration loading rate, L/day/m² [gal/day/ft²]
Texture	Structure		
	Shape	Grade	
COS, S, LCOS, LS	--	0SG	65.1 [1.6]
FS,VFS,LFS,LVFS	--	0SG	40.7 [1.0]
CSL, SL	--	0M	24.4 [0.6]
	PL	1	20.3 [0.5]
		2,3	12.2 [0.3]
	PR/BK /GR	1	30.9 [0.76]
		2,3	40.7 [1.0]
FSL,VFSL	--	0M	20.3 [0.5]
	PL	1,2,3	0.0 [0.0]
	PR/BK /GR	1	24.4 [0.6]
		2,3	32.6 [0.8]
L	--	0M	20.3 [0.5]
	PL	1,2,3	-
	PR/BK /GR	1	24.4 [0.6]
		2,3	32.6 [0.8]
SIL	--	0M	8.1 [0.2]
	PL	1,2,3	0.0 [0.0]
	PR/BK /GR	1	24.4 [0.6]
		2,3	32.6 [0.8]
SCL, CL, SICL	--	0M	0.0 [0.0]
	PL	1,2,3	0.0 [0.0]
	PR/BK /GR	1	12.2 [0.3]
		2,3	24.4 [0.6]
SC, C , SIC	--	0M	0.0 [0.0]
	PL	1,2,3	0.0 [0.0]
	PR/BK /CR	1	0.0 [0.0]
		2,3	16.3 [0.4]

COS – Coarse Sand		LVFS – Loamy Very Fine Sand		SI – Silt	
MS –Medium Sand		COSL – Coarse Sandy Loam		SCL – Sandy Clay Loam	
LCOS – Loamy Coarse Sand		MSL – Medium Sandy Loam		CL – Clay Loam	
LMS – Loamy Medium Sand		FSL – Fine Sandy Loam		SICL – Silty Clay Loam	
FS – Fine Sand		VFSL – Very Fine Sandy Loam		SC – Sandy Clay	
LFS – Loamy Fine Sand		L – Loam		SIC – Silty Clay	
VFS – Very Fine Sand		SIL – Silt Loam		C – Clay	HC – Heavy Clay
PL – Platy	PR – Prismatic	BK – Blocky	GR – Granular	M – Massive	SG—Single Grain
0 – Structureless	1 – Weak	2 – Moderate	3 – Strong		

[44] Alberta Municipal Affairs. 2010. Edmonton, AB.



Note: Plotting the percentage of sand and clay provides the remaining percentage of silt.

Figure D-4. Soil texture classification triangle[45]

[45] Alberta Private Sewage Systems Standard of Practice 2009. Alberta Municipal Affairs, Edmonton, AB.