Collecting and Using Rainwater at Home

A Guide for Homeowners

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Introduction

Canada is considered a water-rich nation. However, certain regions across the country now experience water scarcity on a seasonal or ongoing basis. Consequently, a growing number of Canadian homeowners and municipalities are interested in water conservation measures. Rainwater harvesting is a great way of reducing your consumption of municipally treated water by using what Mother Nature provides to us for free.

Figure 1 The Great Lakes are the largest system of fresh surface water on earth, containing roughly 18 per cent of the world supply[1]

Water usage changes in Canada—A good news story

Significant changes have occurred in Canadian water usage patterns over the last decade. While the overall municipal demand for water has risen on account of a growing population, the water use per person has fallen. This is in part due to efforts deployed by municipalities to encourage residents to use less water. For example, the City of Calgary has put in place measures to achieve a 30-per-cent reduction in water use by 2033. Universal water metering, tracking per capita daily usage and peak day usage have helped the City measure its success.[2]

Similarly, through expansion of conservation and efficiency measures, the City of Guelph, Ontario, plans to achieve a 15-per-cent reduction in average day water use by 2017 and a 20-per-cent reduction by 2025.[3] Like Calgary, Guelph is implementing water metering as both a measure and an incentive to conserve water.

However, if more needs to be done to conserve our water resources, alternative sources such as rainwater and greywater offer a way to reduce our water demands.

1. Nature Canada, "Water Facts," *Water Conservation: There is no life without water.*

2. City of Calgary Water Services, *2010 Water Efficiency Plan Update*, p. 6.

3. City of Guelph, *Water Conservation and Efficiency Strategy Update: Final Report*, p. 2.

What is rainwater harvesting?

Rainwater harvesting is the collection and storage of rain for later use. It is an ancient practice, dating back thousands of years, and is still commonly used in many rural places throughout the world. Today, rainwater harvesting is making a comeback in urban centres as an additional source of water for a range of uses in and around the home.

At its simplest, rainwater harvesting consists of a rain barrel placed below your home's downspout to collect water you can then use to water your plants and lawn. A rainwater harvesting system requires:

- a catchment area, typically the roof (but not paved or landscaped areas) to capture the rainfall
- a conveyance system (eavestroughs and downspouts) to move this water to the rainwater storage tank (also known as a cistern);
- a storage system (rain barrel, cistern, tank) to safely store the rainwater; and
- a distribution system (plumbing) or outlet in order to use the rainwater for its intended purpose, like irrigation or toilet flushing

Figure 3 illustrates how a rainwater harvesting system can be incorporated in a typical domestic plumbing system. Depending on local regulations and available treatment options, rainwater can also be used for everything from toilet flushing and laundry to drinking water (typically in remote locations). This means going beyond the barrel to rainwater harvesting systems that are designed to meet your water needs, property conditions and local building codes.

Figure 2 Rainwater harvesting at its simplest: a rain barrel placed below a downspout

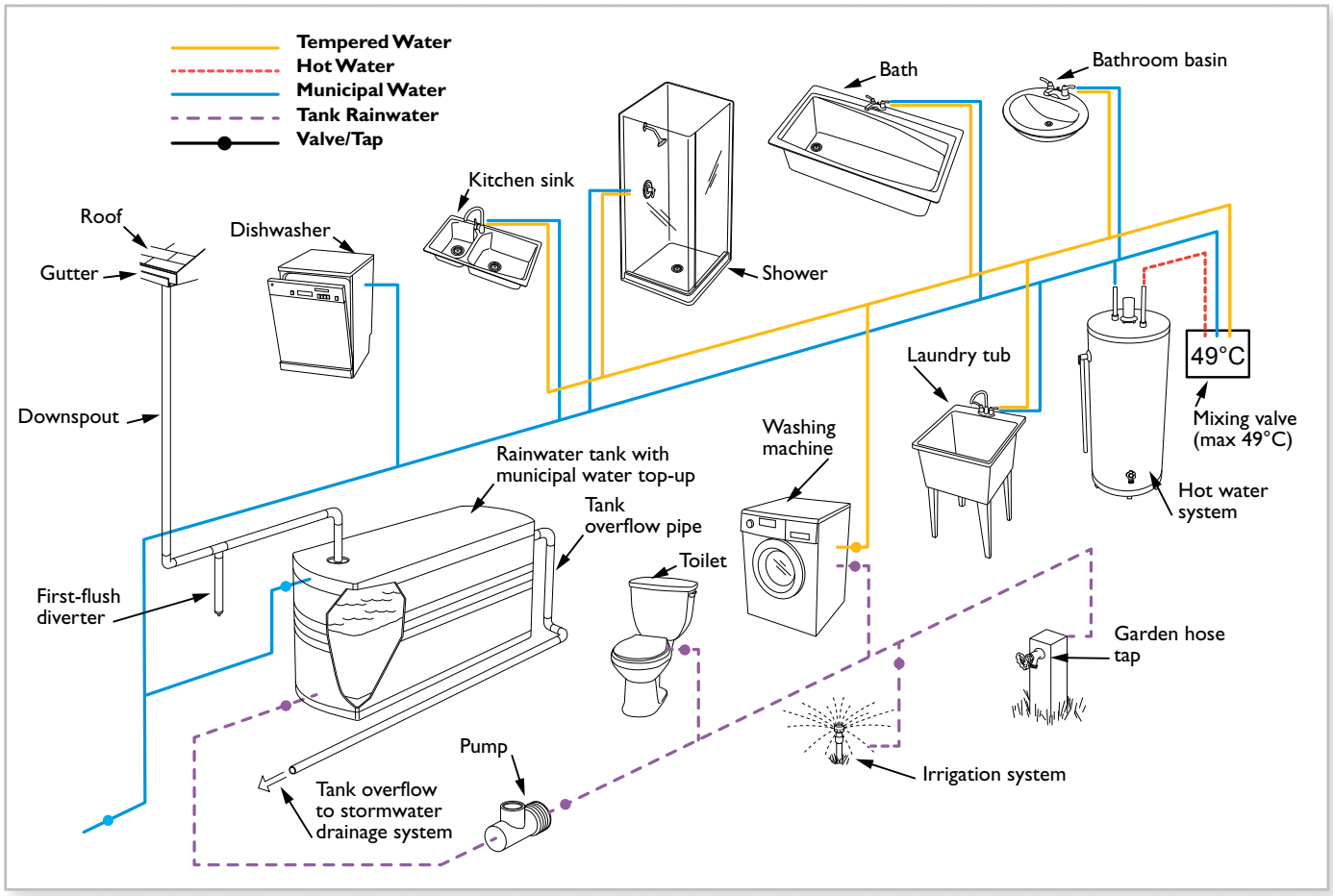

Figure 3 Integration of a rainwater harvesting system into a household plumbing system

Is rainwater harvesting a common practice?

Rainwater harvesting is becoming an accepted practice in a number of countries for a variety of reasons. In Canada, the *2010 National Plumbing Code of Canada* permits the use of rainwater for toilet and urinal flushing as well as subsurface irrigation.[4]

Internationally, many jurisdictions have already widely accepted rainwater harvesting practises. In South Australia, almost 50 per cent of the population lives in houses equipped with a rainwater tank. Rainwater harvesting is mandated for new homes in Queensland. In the southwestern United States, rainwater collection is common, and the State of Texas requires rainwater harvesting for large government buildings. In Germany, Belgium and Japan, rainwater collection is encouraged to reduce runoff going into the stormwater infrastructure. The following table provides a brief look at permitted provincial and international rainwater uses.

[4] Depending on the level of treatment, rainwater can be used for all indoor and outdoor applications. Further or more limited uses may be permitted in your jurisdiction and should be confirmed prior to system installation.

Table 1 Provincially and internationally permitted rainwater uses

Location	Alberta	Ontario	Texas	Germany	Australia
Subsurface irrigation	yes	yes	yes	yes	yes
Surface irrigation			yes	yes	yes
Toilet	yes	yes	yes	yes	yes
Laundry			yes	yes	yes
Hot water					yes
Cold water to shower					yes
Drinking and kitchen					yes

What are the advantages of harvesting rainwater?

Rainwater can help supplement a home's water supply in regions facing water scarcity due to droughts or population growth straining the existing supply. For regions with plenty of water, rainwater harvesting can help reduce greenhouse gas emissions associated with treating and pumping water from a centrally located municipal plant. Rainwater harvesting can also help reduce stormwater runoff from the home—relieving some of the stress on aging municipal stormwater systems.

Rainwater harvesting is less energy-intensive than other alternate sources of water such as desalination and water recycling. It's also free of minerals, thus reducing scale buildup in pipes, and it is sodium-free, which can be good for persons on low-sodium diets if used for drinking water.

Rainwater harvesting benefits our environment and pocketbooks

- **Conserves drinking water** by reducing consumption of municipally treated water, particularly if used for irrigation during dry periods.
- **Lowers water bills** thanks to reduced dependence on municipal water supplies.
- **Helps to reduce basement flooding** in older urban areas by decreasing the amount of rainwater leaving the property and entering storm sewers (these sewers can back up during large storms, which can lead to flooding).
- **Helps to replenish groundwater supplies** by using stormwater on site where it can percolate into the ground and by capturing overflows in cases where the rainwater tank overflows are handled on the home's property (by a rain garden, weeping tile and/or dry well).

What will I learn from this Guide?

Whether you live in a region experiencing water scarcity, or you simply want to enjoy the many economic and environmental benefits of rainwater harvesting, this Guide will introduce you to rainwater harvesting concepts and other important information to ensure that your system meets your needs.

Written for Canadian homeowners, it aims to increase your understanding of rainwater harvesting systems to better prepare you for interactions with the various professionals involved in planning and installing your system. Because rainwater harvesting systems can be complicated, and incorrect design and installation can pose health risks or lead to damage to your house, it is recommended that you develop your system with the help a professional knowledgeable in the design, installation, operation and maintenance of rainwater harvesting systems.

Additional tools such as a glossary of terms, sources of technical information and an easy-to-follow rainwater harvesting system planning checklist are included in the "Tools and Additional Resources" section at the end of this publication.

Who can help me?

The rainwater harvesting professional sector is relatively new in Canada and finding an experienced designer and installer may be difficult. Start by consulting your local authorities, such as your municipal building services department, to determine what professionals are required to design and install a rainwater harvesting system in your jurisdiction. It is recommended that, at a minimum, a plumber review any plans, drawings or specifications for the system to ensure that they meet the plumbing requirements in the local building code.

Getting Started

Prior to designing your system you need to find out which rainwater uses are approved in your region and which of the approved uses are right for your household. Once you know what you can and want to use rainwater for, you can then determine the amount of water you will need to meet your needs which in turn determines how much rainwater you need to collect. An experienced professional can help you through this process, or you can do it on your own by following the steps and answering the questions outlined in this section.

What can I use rainwater for?

In Canada, legislation is still in development for alternative water supplies, such as rainwater harvesting and greywater reuse (water from laundry, showers and sinks). While the use of non-potable water for toilet flushing and outdoor irrigation is permitted under the national plumbing code, other applications (such as potable uses) may or may not be permitted in your local jurisdiction. Before setting a goal for rainwater use, check with local authorities (often the building services/plumbing department in your municipality) to determine what rainwater uses are permitted in your area.

Once you know which applications are permitted, determine which ones are right for you. Have you experienced a water shortage? Are you looking for ways to reduce your water bill? What is your motivation for getting a rainwater harvesting system? Defining the goal you want to achieve by harvesting rainwater will help you choose uses that fit your needs. For example, you could choose a seasonal system for outdoor-only use to water your garden or a year-round indoor system to flush toilets and do laundry in your remote cottage.

Asking the right questions

When contacting your municipal/provincial authorities to obtain information about provincial codes and local bylaws and their implications for your rainwater harvesting system, ask them for written responses to the following questions:

- What rainwater uses are permitted?
- Are there site restrictions (zoning, setbacks, etc.)?
- Are there special system designer/installer requirements? Does the work have to be undertaken by a certified engineer, plumber or other authority?
- What permits are needed (plumbing, electrical, building, etc.)? Are there any special permit requirements?
- Are there any incentive or tax rebate programs? If so, what are their requirements?

Ensure you get the contact information of the individual providing the responses, as this will make it easier to get clarifications at a later date.

Figure 4 A properly designed rainwater harvesting system can provide water for lawn and garden use through the summer—even during a municipal watering ban

Depending on where you live, it is also important to consider the seasonal availability of rainwater. For example, if precipitation comes primarily in the form of snow during winter, you may not be able to rely on your rainwater system for year-round supply as it will not be regularly replenished.

How much rainwater do I need?

The amount of rainwater you will need depends on a multitude of factors, including:

- the end use of harvested rainwater (irrigation, toilet flushing, etc.);
- the age and efficiency of plumbing fixtures (how much water they use);
- the number of people in your household; and
- your household's water consumption habits (such as outdoor watering or toilet flushing frequency).

Water conservation

Before installing a rainwater harvesting system, it makes good sense to ensure that you are currently using water wisely in and around your home.

- Replace older, inefficient fixtures (such as toilets and faucets) with newer, water conserving models. Check for the WaterSense® logo on new products to ensure that they meet water efficiency criteria set out by the EPA in the U.S. and adopted in Canada.[5]
- Examine your outdoor water use and see where you can make changes by watering less often or selecting native plants for your garden that are better able to handle dry conditions.[6]

By saving water in and around your home, you optimize your rainwater harvesting system. Greater water consumption means you would need a larger system, and that means higher installation and operating costs.

Figure 5

When replacing old fixtures, choose new water conserving models that carry the WaterSense® logo

[5] For more information about water-efficient fixtures, consult the following CMHC publications: *Household Guide to Water Efficiency* (product no. 61924) and *About Your House: Buying a Water-Efficient Toilet* (product no. 62935).

[6] For more information on reducing your outdoor water use, consult the following titles from CMHC's *About Your House* series: *Low-Maintenance Lawns* (product no. 63488), *Rain Gardens: Improve Stormwater Management in Your Yard* (product no. 63490) and *Water-Saving Tips for Your Lawn and Garden* (product no. 62042).

Figure 6 Conserve water in your garden by selecting plants native to your region that require little or no additional watering

Now that you know what uses you will harvest rainwater for, use worksheet 1 to estimate the amount of water you will need to meet your needs. Volumes presented in the worksheet reflect moderate conservation efforts and are used to perform calculations in examples throughout this Guide. Use the greyed-out columns to estimate your water usage for relevant activities by multiplying the provided per person volumes by the number of persons in your household.

Your household's water use may be lower or higher than these figures, depending on habits and conservation measures. However, the figures provide reasonably good estimates of water consumption by each end use for illustrative purposes.

If you have an automatic irrigation system, your outdoor water use will most likely be significantly higher than calculated in worksheet 1. To estimate your water use, record your water meter reading before and after the irrigation system runs—the difference is the average water use per cycle. To determine your weekly or monthly use, multiply your water use per cycle by the number of times your irrigation system runs per week or per month.

Worksheet 1 Residential water consumption per household activity

Activity	**A** Daily (L/person)	Column **A** x No. of persons	**B** Weekly (L/person)	Column **B** x No. of persons	**C** Monthly (L/person)	Column **C** x No. of persons	**D** Yearly (L/person)	Column **D** x No. of persons
Shower	33.9		237.3		1,017.0		12,373.5	
Baths	7.1		49.7		213.0		2,591.5	
Faucets	30.2		211.4		906.0		11,023.0	
Dishwasher	3.0		21.0		90.0		1,095.0	
Laundry	46.7		326.9		1,401.0		17,045.5	
Toilets	41.3		289.1		1,239.0		15,074.5	
Leaks and other	33.2		232.4		996.0		12,118.0	
Outdoor	27.9		195.3		837.0		10,183.5	

Source: Adapted from City of Guelph, *Water Conservation and Efficiency Strategy Update: Final Report*, p. 66.

EXAMPLE Water consumption for a typical household of four

Table 2 summarizes the estimated water consumption of a family of four who plans on using rainwater for outdoor irrigation, laundry and toilets. Estimates were calculated using worksheet 1. By totalling the columns, you can determine how much rainwater would be required to meet your needs on a daily, weekly, monthly and yearly basis.

Table 2 Estimated water consumption for a family of four (laundry, toilets and outdoor irrigation)

Activity	**Daily (L)** Column A x 4	**Weekly (L)** Column B x 4	**Monthly (L)** Column C x 4	**Yearly (L)** Column D x 4
Laundry	187	1,308	5,604	68,182
Toilets	165	1,156	4,956	60,298
Outdoor	112	781	3,348	40,734

How much rainwater can I collect?

The amount of water that can be captured for rainwater harvesting is based upon local rainfall[7] and the size of the catchment area (the roof area used for rainfall collection).

The general calculation for determining how much rainfall can be captured is that, for every one millimetre of rain that falls across a square metre catchment area, one litre of water can be captured. So if you have a roof with a catchment area of 100 m² and receive around 650 mm of rainfall annually, then in theory you can collect up to 65,000 L per year.

Unfortunately, not all rainfall can be collected. Heavy rains will overflow the eavestroughs, reducing rainwater capture, and some rainfall will be lost through pre-filtration (see "Pre-filtration devices" on page 26), evaporation and leaks, and some rainwater may be absorbed by the roofing material. A rough rule of thumb is that approximately 80 per cent of the annual rainfall that falls on the catchment area can be collected if the tank is large enough and doesn't overflow.

Source: The Watercache Blog (www.watercache.com/blog/)

Figure 7 Rain barrels have limited storage capacity and need an overflow pipe that leads water away from the house to prevent damage to the house and foundation

[7] Local rainfall data can be obtained from private weather information providers, such as the Weather Network. A map detailing aspects of precipitation in Canada is available from Natural Resources Canada at http://atlas.nrcan.gc.ca/

Tank overflow is a major factor impacting how much rainwater you can collect. If the tank is full while it rains, all of the water that could have been collected is lost, as it simply overflows from the tank. Larger tanks help to ensure that there is enough extra storage capacity to handle big storms, but big tanks are also more expensive and require more space or bigger excavations if buried. Often a balancing act is required—selecting a tank that is big enough to meet demands but small enough to minimize the overall cost and size of the system.

EXAMPLE Annual rainfall collection calculation

Annual rainfall data for your location	= _____ mm (A)
Catchment roof area	= _____ m^2 (B)
Maximum rainwater collection	= A x B = _____ x _____ = _____ L (C)
Adjustment for losses	= C x 0.8 = _____ x 0.8 = _____ L .

It's important to note that rainwater harvesting may not be able to meet all your needs entirely at all times of the year. You may need to have a "top-up" (also called a "make-up") system to get additional water from a municipal water supply, well or water truck (if you live in a remote area without a well) to replenish the rainwater tank if necessary. More information about top-up systems is provided on page 29.

EXAMPLE Rainwater collection that does not meet estimated consumption

For example, let's consider a family of four who lives in Edmonton, in a house with a roof area of 90 m^2, and wishes to collect enough water to flush its toilets year-round. In our previous example, we estimated that a family of four would need about 60,298 L of water annually to meet its toilet flushing needs.

Annual rainfall data in Edmonton	= 346 mm (A)
Catchment roof area	= 90 m^2 (B)
Maximum rainwater collection	= A x B = 346 mm x 90 m^2 = 31,140 L (C)
Adjustment for losses	= C x 0.8 = 31,140 L x 0.8 = 24,912 L.
Top-up supply needed	**= 60,298 L - 24,912 L = 35,386 L.**

In this example, rainwater could supply approximately 40 per cent of the water needed for toilet flushing. The difference of about 35,000 L would have to come from an alternate water supply (such as a well or the municipal water supply).

Now that you have a good understanding of rainwater needs and collection abilities, you are ready to size your rainwater harvesting system.

Sizing Your Tank

Rainwater storage tank sizes vary from less than one hundred litres to tens of thousands of litres for residential systems. There are a variety of ways to size a rainwater storage tank. For residential use, the most common include:

1. sizing the tank to provide a specific volume of water during dry periods (for example, to meet outdoor watering needs for one week); and
2. sizing the tank to maximize water savings while keeping tank size to a minimum.

Of these approaches, the first method (sizing the tank to hold a given volume of rainwater) is easiest to calculate by a do-it-yourself homeowner, whereas the other methods require more involved calculations. In both cases, it is a good idea to get your calculation verified by an experienced professional before purchasing a tank.

Figure 8 This 1,000-L indoor rainwater tank, which supplies water for toilet flushing in three apartment-style condominium units, is equipped with a top-up system to ensure water is always available

How do I calculate my tank size if I want it to hold a specific volume?

It is important to note that sizing a tank for a specific volume (option 1) assumes that the tank is full at the time that dry conditions begin. This may not always be the case, especially if there are only very small rainfalls leading up to the dry period. It is recommended that you use an "oversize factor" to make the tank a little bigger than you think you'll need, so that when dry conditions start, you'll have enough water supply even if your tank isn't completely full.

EXAMPLE Sizing the tank for a specific volume

Family A

Family A, a household of four, lives in a municipality that often implements outdoor watering bans when water levels are low in the summer. Family A would like to use its rainwater harvesting system to provide enough water to meet its outdoor watering needs during watering bans. The family establishes that a month's supply of rainwater will be sufficient to meet that need. Here is how to estimate the tank size it needs:

Estimated monthly water consumption*	= 3,348 L
Oversize factor	= 1.25**
Water consumption x oversize factor	= 3,348 L x 1.25
Recommended tank size for family A	= 4,185 L (round up to 4,200 L)

Based upon the oversize factor, a 4,200-litre tank is recommended to provide a greater assurance that the rainwater harvesting system can supply water for outdoor watering during one month of drought conditions. However, the actual water savings and the length of time the system can continue to supply rainwater will vary, depending on water usage and the volume of rainwater in the tank at the onset of dry conditions.

Family B

Family B, another household of four, lives in a remote seasonal cottage from June to August and would like to harvest rainwater to supply water for toilet flushing and clothes washing for the summer months. The tank size calculation will be as follows:

Estimated water consumption*	= (5,604 L + 4,956 L) x 3 months = 31,680 L
Oversize factor	= 1.25**
Water consumption x oversize factor	= 31,680 L x 1.25
Recommended tank size for family B	= 39,600 L

For a household of four, a storage tank with at least 39,600 litres should provide enough rainwater to last for a period of three months for toilet flushing and laundry. Again, actual savings will vary depending upon the household's actual water usage and the amount of rainwater in the tank when dry conditions begin.

* From our example on page 10

** This makes the tank 25 per cent larger than necessary to provide for times when the tank isn't completely full when dry periods begin. Smaller or larger oversize factors can be applied based on experience.

How do I calculate my tank size if I want to maximize water savings?

To size the rainwater storage to maximize water savings, more complex calculations are necessary. To simplify this process, these calculations have been performed, and recommendations are provided in the *Guidelines for Residential Rainwater Harvesting Systems Handbook*. The Handbook provides tables of recommended storage tank capacities based on rainwater demand, regional rainfall data and roof catchment areas. Data tables from the Handbook for the Atlantic provinces, Ontario and Quebec, the Prairie provinces and British Columbia are provided at the end of this section.

EXAMPLE Sizing the tank using the data tables

Going back to families A and B from our earlier examples, let's recalculate the recommended storage capacity of the tank for various roof catchment areas, assuming that both families live in British Columbia. To use the tables, we need to use the daily consumption calculated on page 10.

For family A, when rounding up the outdoor water use of 112 litres per day to 150 litres per day, the recommended storage tank will be as follows:

- 4,000 L for a roof area of 50 m²
- 5,000 L for a roof area between 100 and 200 m²
- 4,000 L for a roof area between 250 and 900 m²
- 5,000 L for a roof area between 1,000 and 3,000 m²

For family B, the sum of daily toilet (165 litres) and laundry (187 litres) use is rounded down to 350 litres per day, and the recommended storage tank will be as follows:

- 4,000 L for a roof area of 50 m²
- 5,000 L for a roof area of 100 m²
- 7,500 L for a roof area between 150 and 2,000 m²
- 5,000 L for a roof area between 2,500 and 3,000 m²

Reading sizing data tables

Reading the tank-sizing tables at the end of this section can be a little confusing at first. As the size of the catchment area increases (as you move from left to right in the tables), the recommended tank sizes become larger, up to a certain point where tank sizes don't get any bigger and can even drop down in size.

The reason for the drop is that, while larger catchment surfaces catch more rainwater than your water demand, this additional rainwater is merely being stored in the tank unused. With smaller roofs, you need a bigger tank so that you can capture all of rain contacting the roof, even the rainfall from infrequent large storms. If you have a larger roof, you will be able to fill up a smaller tank more quickly, and more often, meaning that you will be able to have the same water savings as you might achieve with a larger tank.

What else should I consider when sizing my tank?

Tanks come in a range of sizes, shapes and storage capacities. A key condition in determining the size of the tank is the size of the property or the room in the house where the tank will be located. If you have a large lot, you can likely support as large a tank as you require, since it can be easily buried. For smaller properties, space may be a limiting factor. Local building codes determine how

far tanks must be located from property lines, wells, septic systems and other structures. These setback distances must be considered in your design and choice of tank.

Figure 9 If space is not an issue, you can choose as big a tank as you need

From our example above, if family B's cottage has a roof catchment area of 500 m², its optimum tank size would be of 7,500 L. In terms of size, this corresponds to a 2- to 3-m high tank with an 8-m diameter. Table 3, which gives a general idea of the storage capacity of cylindrical tanks based on their height (assuming they stand on end) and diameter, is presented here as an indication of tank size only.

Table 3 Cylindrical tank capacities in litres and gallons

Height	Diameter		
m	1.8 m	3.7 m	5.5 m
1.8	4,804 L	19,215 L	43,233 L
2.4	6,405 L	25,620 L	57,640 L
3.1	8,006 L	32,024 L	72,051 L
3.7	9,607 L	38,429 L	86,462 L
4.3	11,209 L	44,834 L	100,874 L
4.9	12,810 L	51,235 L	115,285 L
5.5	14,411 L	57,640 L	129,696 L
6.1	16,012 L	64,045 L	144,107 L

Source: Adapted from: Texas Water Development Board, *The Texas Manual on Rainwater Harvesting*, p.15

Table 4 Recommended storage tank capacities for catchment areas and rainwater demands for rainwater harvesting systems in the Atlantic provinces

Rainwater Demand (L/day)	Optimum Rainwater Tank Capacity (L)—coloured cells																		
	Roof Catchment Area (m²)																		
	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	4,000	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
150	4,000	4,000	4,000	4,000	4,000	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
200	4,000	5,000	5,000	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
250	4,000	5,000	5,000	5,000	5,000	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
300	4,000	7,500	7,500	7,500	5,000	5,000	5,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	5,000	5,000	5,000	5,000	5,000
350	4,000	7,500	7,500	7,500	7,500	7,500	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
400	4,000	7,500	7,500	7,500	7,500	7,500	7,500	7,500	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
450	4,000	7,500	7,500	7,500	7,500	10,000	7,500	7,500	7,500	7,500	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
500	4,000	7,500	7,500	7,500	7,500	10,000	10,000	7,500	7,500	7,500	7,500	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
600	4,000	7,500	7,500	7,500	7,500	10,000	10,000	10,000	10,000	10,000	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	5,000
700	4,000	7,500	7,500	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500
800	4,000	7,500	7,500	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500
900	4,000	7,500	7,500	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	7,500	7,500	7,500	7,500
1,000	4,000	7,500	7,500	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
1,500	4,000	7,500	7,500	10,000	10,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
2,000	4,000	7,500	7,500	10,000	10,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000
2,500	4,000	7,500	7,500	10,000	10,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000
3,000	4,000	7,500	7,500	10,000	10,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000

Recommended rainwater storage tank capacities generated assuming:

- historical rainfall for St. John's, N.L., from 1950 to 2005 (median annual rainfall: 1,156 mm); and
- optimum rainwater storage tank capacity values include an assumption of a 20 per cent unused volume (typically referred to as 'dead space').

Source: CMHC, *Guidelines for Residential Rainwater Harvesting Systems Handbook* (Ottawa: CMHC, 2011), p. 109.

Table 5 Recommended storage tank capacities for catchment areas and rainwater demands for rainwater harvesting systems in Ontario and Quebec

Rainwater Demand (L/day)	Optimum Rainwater Tank Capacity (L)—coloured cells																		
	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	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
150	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
200	2,000	5,000	5,000	5,000	5,000	5,000	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
250	2,000	5,000	5,000	7,500	5,000	5,000	5,000	5,000	5,000	5,000	5,000	4,000	4,000	4,000	5,000	5,000	5,000	5,000	5,000
300	2,000	5,000	5,000	7,500	7,500	7,500	7,500	7,500	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
350	-	5,000	5,000	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
400	-	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	7,500	5,000	5,000	5,000	5,000
450	-	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	7,500	7,500	7,500	7,500	7,500
500	-	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	7,500	7,500	7,500	7,500	7,500
600	-	5,000	5,000	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	10,000	10,000	7,500	7,500	7,500	7,500	7,500	7,500
700	-	5,000	5,000	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	10,000	10,000	10,000	10,000	10,000	10,000	10,000	7,500
800	-	5,000	5,000	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
900	-	-	5,000	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
1,000	-	-	5,000	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
1,500	-	-	5,000	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	10,000	10,000	10,000	10,000	10,000	15,000	15,000	15,000
2,000	-	-	5,000	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	10,000	10,000	10,000	10,000	10,000	15,000	15,000	15,000
2,500	-	-	-	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	10,000	10,000	10,000	10,000	10,000	15,000	15,000	15,000
3,000	-	-	-	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	10,000	10,000	10,000	10,000	10,000	15,000	15,000	15,000

Recommended rainwater storage tank capacities generated assuming:

- historical rainfall for Toronto, Ont., from 1961 to 2005 (median annual rainfall: 678 mm); and
- optimum rainwater storage tank capacity values include an assumption of a 20 per cent unused volume (typically referred to as 'dead space').

Source: CMHC, *Guidelines for Residential Rainwater Harvesting Systems Handbook* (Ottawa: CMHC, 2011), p. 110

Table 6 Recommended storage tank capacities for catchment areas and rainwater demands for rainwater harvesting systems in Prairie provinces

Rainwater Demand (L/day)	Optimum Rainwater Tank Capacity (L)—coloured cells																		
	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 assuming:

- historical rainfall for Edmonton, Alta., from 1961 to 2005 (median annual rainfall: 346 mm); and
- optimum rainwater storage tank capacity values include an assumption of a 20 per cent unused volume (typically referred to as 'dead space').

Source: CMHC, *Guidelines for Residential Rainwater Harvesting Systems Handbook* (Ottawa: CMHC, 2011), p. 111

Table 7 Recommended storage tank capacities for catchment areas and rainwater demands for rainwater harvesting systems in British Columbia

Rainwater Demand (L/day)	Optimum Rainwater Tank Capacity (L)—coloured cells																		
	Roof Catchment Area (m²)																		
	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	4,000	4,000	4,000	4,000	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
150	4,000	5,000	5,000	5,000	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
200	4,000	5,000	7,500	7,500	5,000	5,000	5,000	5,000	5,000	4,000	4,000	4,000	4,000	4,000	5,000	5,000	5,000	5,000	5,000
250	4,000	5,000	7,500	7,500	7,500	7,500	7,500	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
300	4,000	5,000	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	5,000	5,000	5,000	5,000	5,000	5,000	5,000
350	4,000	5,000	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	5,000	5,000
400	4,000	5,000	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500
450	4,000	5,000	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	10,000	10,000	7,500	7,500	7,500	7,500	7,500	7,500	7,500
500	4,000	5,000	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	10,000	10,000	10,000	10,000	10,000	7,500	7,500	7,500	7,500
600	4,000	5,000	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
700	4,000	5,000	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
800	4,000	5,000	7,500	7,500	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
900	4,000	5,000	7,500	7,500	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
1,000	4,000	5,000	7,500	7,500	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
1,500	4,000	5,000	7,500	7,500	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	15,000	15,000
2,000	4,000	5,000	7,500	7,500	10,000	10,000	10,000	10,000	10,000	10,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000
2,500	4,000	5,000	7,500	7,500	10,000	10,000	10,000	10,000	10,000	10,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000
3,000	4,000	5,000	7,500	7,500	10,000	10,000	10,000	10,000	10,000	10,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000

Recommended rainwater storage tank capacities generated assuming:

- historical rainfall for Vancouver, B.C., from 1950 to 2005 (median annual rainfall: 1,102 mm); and
- optimum rainwater storage tank capacity values include an assumption of a 20 per cent unused volume (typically referred to as 'dead space').

Source: CMHC, *Guidelines for Residential Rainwater Harvesting Systems Handbook* (Ottawa: CMHC, 2011), p. 112

Designing Your System

To have a rainwater harvesting system that works efficiently and meets your needs, it is important to consider how each of its components can affect the performance of the system as a whole. The following section discusses common system components and features and provides design and installation factors to consider when planning your system. It is not intended to be a design guide but rather to give you an idea of what's involved in the design of a rainwater harvesting system. This will prepare you to discuss the information in this section with your rainwater harvesting system designer.

What do I need to know about key system components?

Roof

Roofing materials can impact the quantity and quality of rainwater collected during rainfalls. Some roofing materials can add harmful contaminants to rainwater as it flows over the roof surface making it unsuitable for use as drinking water. Potential contaminants from common roofing materials are outlined in table 8. More porous types of materials, such as asbestos shingles, clay or concrete tiles, or wood shingles, result in greater water loss.

Figure 10 Roofing material, such as wood shingles, can impact the quantity and quality of rainwater you can collect

Table 8 Contaminants from common roofing materials

Roofing materials	Potential contaminants
Asbestos-cement	Asbestos fibres
Terracotta tiles	Coating materials, colour
Paints and other coatings	Lead, acrylic leachates, bitumen-based contaminants
Wood shingles	Pesticides, pressure-treated wood, creosote
Metal roofing	Zinc

Metal and slate roofing materials offer reduced water-loss potential thanks to their smooth surfaces, and both can be coated in non-toxic materials, making them appropriate for rainwater systems used to provide drinking water.

Care should be taken to ensure that metals used for roofing, flashing and eavestroughs are compatible with any materials used for the rainwater cistern. For instance, lead flashing should not be used for systems providing drinking water or water to irrigate edible plants.

Eavestroughs and downspouts

Collecting rainwater depends on having properly sized eavestroughs and the correct number of downspouts. Water that overflows from eavestroughs in heavy rains can't be captured and stored. Also, as the overflow can run down the building and pool against the foundation there is also a potential for moisture damage to the home.

Figure 11 Overflowing eavestroughs that are free of debris can indicate improperly-sized or sloped eavestroughs or an incorrect number of downspouts to drain the eavestroughs

Check local regulations to see if there are any building requirements that specify gutter and downspout size as well as the number of and distance between downspouts.

Credit: Bob Burgess (www.rainwaterconnection.com)

Figure 12 A properly sized and sloped eavestrough leads rainwater to the desired downspout, reducing the occurrence of water overflows

Failure to maintain (clean out) gutters and downspouts may cause overflows and water loss. Debris accumulated in the gutters, downspouts and any other part of the rainwater conveyance system (discussed further below) may also be washed into the storage tank during large rainfalls—which can negatively impact the quality of the rainwater supplied by the harvesting system. It's important to add appropriate pre-filtration devices to protect the systems and maintain them regularly.

Source: www.mastermylist.com/gutters/

Figure 13 Failure to maintain eavestroughs and downspouts can lead to problems: this downspout is completely clogged by accumulated debris and had to be replaced

Rainwater conveyance network piping

The conveyance network includes all plumbing used to take rainwater from the roof catchment area to the tank. Pipe materials, sizes and slope are governed by local and provincial codes. Make sure that all above-ground piping is UV-resistant and that the appropriate piping type is used for above- or below-ground installations.

Tank

Tanks can be located above ground, below ground or even inside the home, shed or garage. Rainwater storage tank sizes can start anywhere from less than one hundred litres to tens of thousands of litres for residential systems. Your choice of rainwater cistern or tank depends on:

- the amount of water you wish to store;
- the size of your catchment area;
- the tank's location (above ground, below ground, inside the home/garage/shed);
- the intended water use (year-round use or seasonal use);
- local weather conditions (for example, in areas with freezing temperatures during winter, the tank will need to be protected from frost or drained during the winter);
- the availability of space for access and installation;
- local bylaws and building code requirements;
- aesthetics; and
- costs.

Tank materials and structural integrity are regulated through building codes and standards. In Canada, all underground tanks must comply with the Canadian Standards Association (CSA) B66-10 Standard, *Design, material, and manufacturing requirements for prefabricated septic tanks and sewage holding tanks,* and all cisterns will have to comply with the CSA B126 Standard, *Potable Water Cisterns*, once this standard is approved and implemented. Ensure that your tank meets all requirements before purchasing.

In Canada, the two most commonly utilized materials for rainwater storage are plastic tanks (polyethylene/polypropylene) and concrete tanks (pre-cast concrete or cast-in-place concrete). Other materials that are available though less commonly used for residential systems are fibreglass, metal, wood and flexible storage bags.

Polyethylene or polypropylene tanks are most common. Durable and lightweight, they are available in a range of size, shape and colour options. Depending on the model, these plastic tanks are typically suitable for above- or below-ground installation. When purchasing a plastic tank, choose a pigmented tank as paint does not adhere well on polyethylene or polypropylene surfaces.

Source: www.mastermylist.com/gutters/

Figure 14 Plastic tanks are most common in Canada

Concrete tanks are typically only used in below-ground systems. Cast-in-place tanks are usually formed as a part of a building's foundation. Although there's a potential risk of cracks or leaks, concrete tanks are reparable and typically offer a lower cost per litre than plastic tanks at larger storage capacities of 10,000 L or more.

Fibreglass tanks are lightweight compared to concrete or plastic alternatives. They can last for decades without deterioration, can be painted and are easily repaired. Depending on the model, fibreglass tanks can be used above or below ground.

Galvanized steel tanks are low-cost and are used in above-ground installations only. They can be lined to reduce corrosion.

Stainless steel tanks offer good corrosion resistance. They are more costly and are for above-ground installation only.

Credit: Bob Burgess (www.rainwaterconnection.com)

Figure 16 A 45,500-L steel cistern

Metal tanks are generally lightweight, easy to transport and to relocate and are for above-ground installation only. Use an approved liner as there is a potential for rusting and leaching of zinc in tanks made of an aluminum-zinc combination.

Wood tanks are for above-ground use only. They are often constructed from redwood, cedar, pine, or cypress wrapped in steel cables and lined with plastic. Durable, decay-resistant, aesthetically pleasing, wood tanks offer good insulation properties and can be dismantled and moved.

Credit: Bob Burgess (www.rainwaterconnection.com)

Figure 15 Concrete underground rainwater tank (10,600 L) being lowered into place

Flexible bags or bladders are made of heavy duty flexible geotextile fabric that fill via the top or side and can include a steel frame. They are used in above-ground installations and can be used in confined spaces, like crawl spaces. They are more difficult to clean than conventional tanks but can be easily drained and stored during the winter.

Distribution system

The distribution system includes the pipes that transport rainwater from the tank to the fixtures connected to harvesting system. These pipes need to be selected and installed so that they are suitable for handling water under pressure, and are the appropriate size based upon the number of fixtures connected and the flow rates they need. The choice of pipe size and material is regulated by the local and provincial codes.

Protection from overflow damage

During periods of heavy rain, or low water usage, the tank may overflow. Rainwater cisterns should always have an overflow pipe that is larger than, or at least the same size as, the inlet pipe to ensure that the excess water does not back up into, and overflow, the tank.

If the rainwater harvesting system has a top-up system, it is important that the overflows be discharged at a lower elevation than the air gap in the top-up system (see page 29). If the overflow pipe is higher than the air gap, rainwater may back up into the top-up pipe and discharge through the air gap—which can potentially cause water damage in your basement.

To protect your home from moisture damage, all overflow water should be discharged in an appropriate location away from foundations and other structures. Check with your local jurisdiction to determine what locations are permitted (dry well, infiltration trench, municipal storm sewer, etc.).

Protection against freezing

Conveyance networks and cisterns in all rainwater systems should be protected against freezing. If not, there will be a significant risk of damage and leaking. All below-ground piping and cisterns should be installed below the frost line or adequately insulated to ensure that they don't freeze. Systems that are only used for summer irrigation should be completely drained at the end of the season.

Credit: Bob Burgess (www.rainwaterconnection.com)

Figure 17 An overflow pipe discharges all excess water in an appropriate location away from foundations and other structures

Backflow prevention

Backflow prevention devices are used to ensure that non-potable water cannot flow backwards into a potable water system and contaminate it. These devices are required for non-potable systems under the *2010 National Plumbing Code of Canada.*

Further requirements for maintenance, testing and inspection of backflow prevention devices may also be required under local bylaws to ensure that these devices are in good working order. For rainwater systems with a top-up water supply (see page 29), the easiest way to prevent contamination is to utilize an air gap between the highest water level in the rainwater tank and the potable water point of supply.

Backflow prevention devices may also be used to isolate the house's water from its well or municipal water supply, and to separate supplies of non-potable and potable water inside the house.

What optional system components should I consider?

Pre-filtration devices

Depending on where you live, your roof can collect a variety of contaminants like:

- leaves,
- twigs,
- atmospheric dust,
- pollens,
- pesticide residues, and
- insect, animal and bird waste.

Contamination will vary depending on agriculture or industrial activities in the area, the number of dry days between rainfalls, the location of freeways, the presence of overhanging trees and the season.

Pre-filtration devices (located in the conveyance system prior to the tank) can help remove these contaminants that may collect on the roof. Depending on the size of your roof, some pre-filtration devices may be more economical than others (see cost information on page 46).

Understanding the air gap

The air gap is the space between a water outlet and the flood level. To visualize this, consider the space between your kitchen faucet (water outlet) and the top edge of your kitchen sink at counter height or the height of the overflow prevention drain (flood level). If water was to back up through your kitchen drain and fill your sink, the air gap would prevent drain water from making its way into your faucet and mixing with—and possibly contaminating—your potable water supply. Instead, water would spill over the edge of the counter and onto the floor, or in the picture below, into the overflow drain located just below the faucet. The same air gap principle applies to rainwater tank top-up systems.

Figure 18 An air gap prevents drain water from backing into, and contaminating, the potable water supply from the tap

The most commonly used pre-filtration components include the following:

- **Gutter guards** attached over the top of eavestroughs to prevent debris from entering, accumulating in and blocking the gutters (see figure 19).
- **Downspout filters** installed in line with each downspout connected to the rainwater harvesting system. An alternative, or addition, to gutter guards, downspout filters catch debris after it enters eavestroughs and prevents it from entering the tank. Depending on the filter model, they can be attached to the top of the downspout (in the eavestrough), anywhere along the length of the downspout, or in the ground below the downspout (see figure 20).
- **First-flush devices** installed in line with every downspout connected to the harvesting system. They divert or flush away the first several litres of rainwater containing dust, pollen and animal waste washed from the roof during rainfall. The simplest device is a diverter system that relies on a standpipe that fills with contaminated rainwater and then, once it is full, allows the cleaner rainwater that follows to flow into the storage system (see figure 21).

  The actual amount of water to be diverted will depend on a range of considerations. *The Texas Manual on Rainwater Harvesting* suggests that approximately 40 L of rainwater should be diverted for every 100 m² of catchment (roof) area.
- **Pre-tank filters** attached to eavestroughs, downspouts or to the storage tank (depending on the device). These are a more complex version of the downspout filter, made up of one or more fine mesh screens to prevent finer debris from entering the rainwater storage tank. Pre-tank filters provide higher-quality rainwater that may be used for drinking and drip irrigation purposes.

Credit: Bob Burgess (www.rainwaterconnection.com)

Figure 19 Gutter guards prevent leaves, twigs and other debris from clogging the gutters

Credit: Bob Burgess (www.rainwaterconnection.com)

Figure 20 Downspout filters prevent debris entering the tank

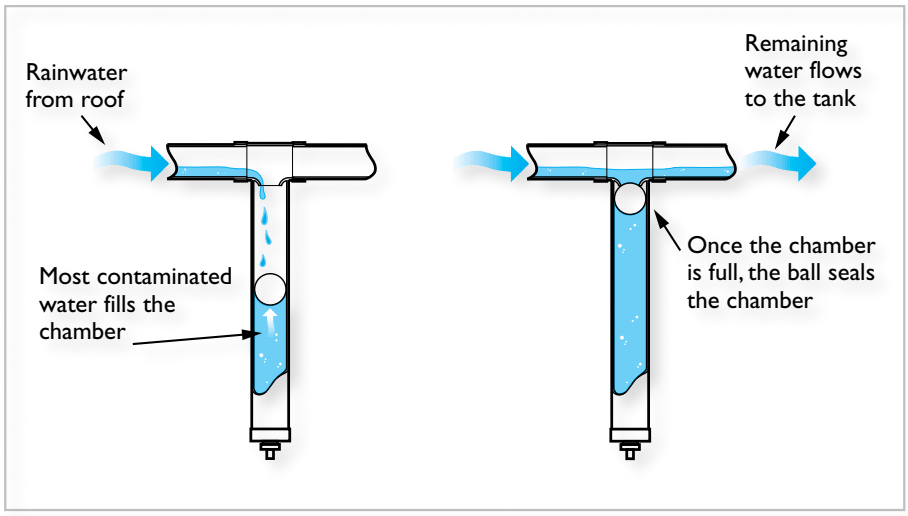

Figure 21 A simple first-flush device: as the diverter chamber fills up with the most contaminated water, the ball rises to eventually seal the pipe and let the cleaner rainwater flow to the storage system; the contaminated water can be later drained away

Pump and pressure tank

If you intend to use your rainwater harvesting system for anything other than filling a watering can to water plants, you will probably need some form of pumping system to more quickly move the rainwater to where you need it, and to provide it at a typical household water pressure.

Consult a pump expert, engineer or rainwater harvesting system designer to help you choose the right pump for your system. Before making a choice, you will need to discuss the pump size (flow rate), type and intended location, as well as the required water pressure.

Key points to consider when choosing a pump are:

- the cistern location;
- the pump type and location (for example, a submersible pump located inside the cistern or a jet pump located near the tank);
- the motor configuration (constant speed, variable-speed drive or variable-frequency drive);
- the number of plumbing fixtures and the respective flow rates of all applications using rainwater (see table 9);
- the number of occupants in your household;
- the number of storeys of your house; and
- the maximum pumping distance (from the pump to the furthest fixture connected to the rainwater system).

Look for a quiet, energy-efficient pump. Make sure the pump has automatic pressure controls that start and stop the pump as needed and prevent it from running when the cistern is empty.

A pressure tank may also be needed to maintain water pressure and minimize pump operation. This should be considered during the rainwater system design and pump selection.

Table 9 Typical flow rates of residential plumbing fixtures

Plumbing fixture	Minimum Flow Rate L/min.	Maximum Flow Rate L/min.
Bathroom sink	6	9
Bathtub	18	18
Toilet	6	6
Shower	6	9
Dishwasher	12	12
Kitchen sink	7	9
Laundry tub	7	9
Washing machine	12	12
Hose tap (15 mm)	12	12
Hose tap (20 mm)	18	18

Top-up system

During periods of drought or overconsumption, or if annual rainfall in your region is not sufficient to supply water for your needs year-round, your tank may run out of rainwater and need to be topped up with potable water from the municipal system or your well. A top-up system will automatically fill the tank once a water-level sensor (such as a float switch) indicates that the water level is too low and the tank needs to be replenished.

To top-up a rainwater tank with water from a back-up supply, four components are required:

- a float switch (located inside the tank);
- an automated valve (also called a solenoid valve);
- an air gap; and
- a top-up drainage pipe.

The top-up system works by placing an electrical float switch inside the storage tank that triggers an automated valve to open when rainwater levels in the tank drop below a set limit. The opening of the valve allows potable water to replenish the tank. To protect the potable water supply from rainwater contaminants that may be in the tank water, an air gap is often installed in the potable water supply line. An air gap is simply a physical vertical break between the potable water supply pipe and the pipe conveying the water to the rainwater tank (see text box on page 26).

Even in the very unlikely instance that rainwater backs up into the drainage piping that conveys potable top-up water to the tank, rainwater cannot come in contact with the potable water supply pipe itself due to the presence of the gap. Instead, the rainwater will overflow at the location of the air gap. This has implications on how you handle overflows from your rainwater tank: you must ensure that excess rainwater from your tank overflows at a lower elevation (height) than your air gap and is drained away to an appropriate location.

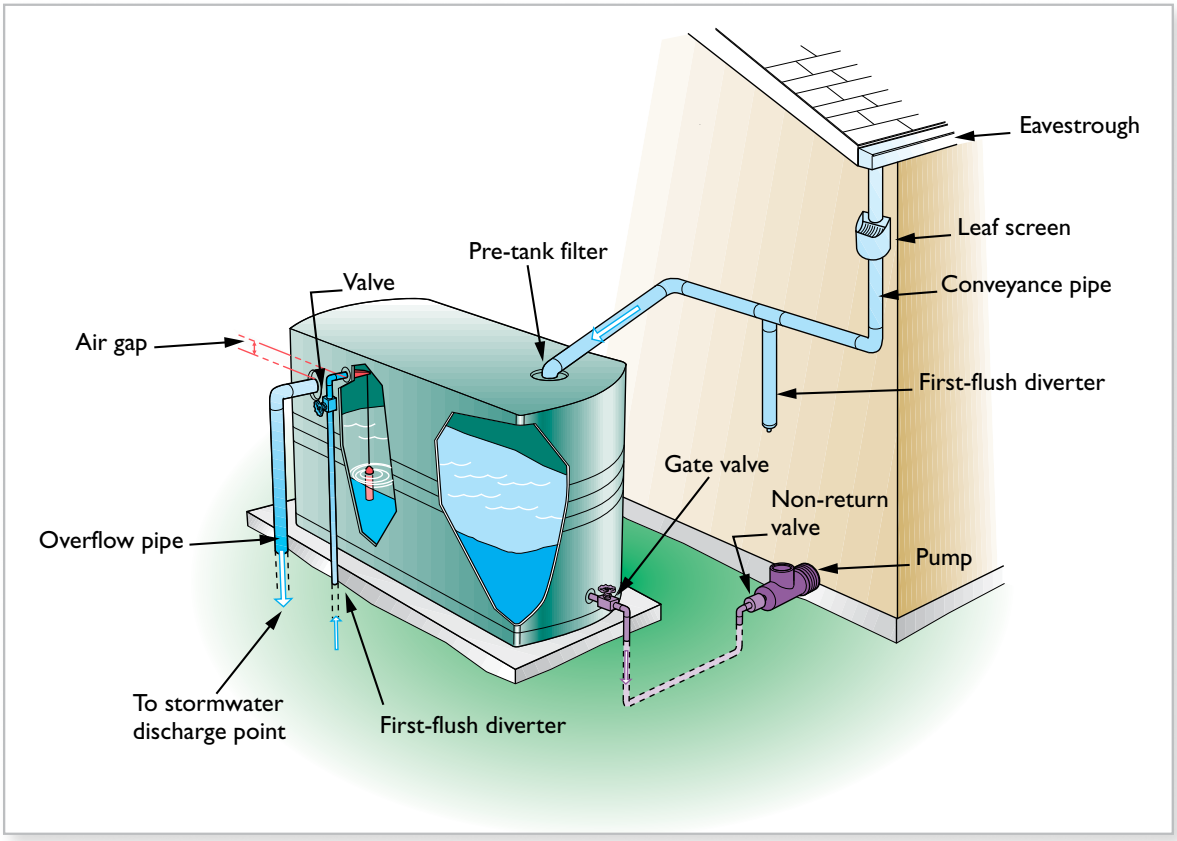

Figure 22 A rainwater harvesting system with top-up supply and an overflow pipe that discharges surplus rainwater to an appropriate location

Post-storage treatment

Rainwater is relatively clean; however, its quality can be affected by environmental pollutants, such as:

- lead and cadmium from industrial activities (smelters, refineries);
- pesticides from agricultural activities;
- hydrocarbons from freeways;
- contaminants from the catchment surface (roofing) materials; and
- wind-deposited debris, leaf litter and animal waste on the catchment surface.

Rainwater may need to be treated, particularly if it is to be used for drinking water.

Pre-storage treatment, as discussed earlier, will reduce the potential for contamination by keeping your rainwater tank free of leaf litter, dust and vermin. However, post-storage treatment can be used to further filter and disinfect your water. Depending on the type of treatment used, colour, odour, suspended solids and pathogens can be reduced.

If you are considering post-storage treatment, it may be useful to ask yourself or your system designer the following questions:

- What will my rainwater be used for and what uses are permitted in my jurisdiction?
- Does the irrigation installer require or recommend any degree of treatment if my rainwater is used for an irrigation system?
- Who will be responsible for the maintenance and monitoring of the treatment system?
- How often does the treatment system need to be maintained (replacement of filters, replenishment of chemicals, etc.)?
- What treatment systems are available in my area?
- Are there any space or noise issues with the selected system?
- What are the capital, operating (energy) and maintenance costs?
- Will the selected treatment system create any waste that must be disposed of?

The following table outlines some of the potential treatment options.

Table 10 Post-storage rainwater treatment options

Purpose	Treatment options
Appearance—To remove contaminants (like hydrogen sulphide, organic matter, manganese, iron) that cause colour, odour and taste issues.	Activated carbon filtration, ozonation, slow sand filtration, reverse osmosis, membrane filtration
Filtration—To removes particles that cause turbidity.	Activated carbon filtration, slow sand filtration, membrane filtration
Disinfection—To remove or inactivate pathogens such as viruses, bacteria and protozoa.	Ultraviolet (UV), chlorine, ozonation, membrane filtration

Source: Adapted from: Texas Water Development Board, *The Texas Manual on Rainwater Harvesting*, p. 24, and CMHC, *Guidelines for Residential Rainwater Harvesting Systems Handbook*, p. 34.

Treated water quality

Currently there are no water quality standards for treated rainwater within Canada nor are there requirements for the type of treatment. Nevertheless, you may wish to consider including some form of filtration and disinfection in your system to reduce potential health risks, particularly if you wish to use the harvested rainwater for drinking. Check with your local health and building department.

Figure 23 Post-storage treatment can be used to reduce the presence of colour, odour, suspended solids and pathogens in your rainwater

What other design requirements should I consider?

As mentioned earlier, it is important to ensure your rainwater harvesting system meets applicable provincial codes and local bylaws and regulations. But other third-party design considerations, such as those of your home insurance provider or of a municipal water efficiency rebate program, should be included in your design, as applicable.

Home insurance provider requirements

Insurance coverage for rainwater harvesting systems may vary depending on the insurance provider and the home insurance plan selected by the homeowner. Common insurance provider concerns about rainwater harvesting systems include:

- rainwater storage tank overflowing into a basement or garage during rainfall;
- water damage to the house and foundation at the point where overflows are discharged;
- improper installation of system;
- improper use of system for applications not permitted by codes; and
- potential for leaks in plumbing due to the weight of horizontal piping when the pipe is full.

To secure proper insurance coverage, or to ensure the continuity of the coverage you already have, it is important to discuss your planned rainwater harvesting system with your insurance provider to make sure that the design and installation are appropriate and in accordance with the insurance provider's requirements.

Green building program requirements

If you are interested in getting your home certified by a green building program, such as *LEED® Canada for Homes*, review program requirements and see if it makes sense for you to incorporate them in your design.

Tax exemption, incentive and rebate requirements

Incentives may be available to help cover the costs of rainwater harvesting systems. To date, the focus of many such incentive programs has been the provision of rebates for the purchase of rain barrels. Check with your local municipality and water utility for information on any available incentives and program requirements.

LEED® Canada for Homes

LEED® Canada for Homes is a rating system that promotes the design and construction of high-performance homes that use less energy, water and natural resources, create less waste, and are healthier and more comfortable for the occupants. Under the water efficiency section of its rating system, the program gives 5 points for the installation of a rainwater harvesting system, and another 4 points for the installation of an outdoor irrigation system using non-potable water.

For more information about *LEED® Canada for Homes*, visit the Canada Green Building Council's website at www.cagbc.org.

Preparing for Installation

While a simple rain barrel can be placed almost anywhere with very little restrictions, a larger rainwater harvesting system must be installed safely, in accordance with local and provincial codes and standards. A cistern may be installed below ground, above ground at grade, inside a building (inside the home or in a garage/shed), or, very rarely, above ground on a stand. The best choice depends on the nature of the property.

What factors should I consider before installation?

Proper installation is essential. An incorrectly installed below-ground tank may collapse if placed in an area subjected to heavy loads (like a driveway) or may "pop up" to the surface if it is buried in an area with a high water table. An above-ground cistern may topple over if placed on unstable soils or on an improperly designed foundation.

Additionally, improper overflow devices may cause water damage to the house and flooding around the house foundation and lead to moisture issues. Systems may freeze and become damaged during winter months unless correctly insulated or emptied.

Consult your local authorities and consider hiring an experienced installer to ensure that the system is installed properly and safely. Even if you choose to do it yourself, consulting a specialist for help is wise, as the technical factors involved can be overwhelming and can undermine your investment.

Whether you choose an above-ground, indoor or underground tank, the following issues need to be considered:

- site selection and lot-line setback distances;
- soil conditions;
- access requirements and restrictions;
- base and anchor requirements; and
- health and safety.

How do I select the proper site?

Proper site selection will help prevent the rainwater system from causing damage to, or being damaged by, existing property features. Before selecting a site, consider the following limiting factors:

- the location of above- and below-ground utility services;
- the location of wells and septic systems;
- the location of building foundations;
- the location of tree roots and groundwater;
- the site's topography, depth to bedrock and soil classification;
- stormwater drainage areas and flood plains;
- property boundaries, easements and rights-of-way;
- driveways, roads and other features that may impact the cistern location; and
- cistern visibility and aesthetics—for you and your neighbours.

As mentioned earlier, the minimum setback distances between your cistern and certain features (such as property boundaries) will be regulated by local codes and standards. Check with your municipality before choosing, locating and installing your system. Once you have identified all applicable limiting factors, select a site that meets all requirements while staying away from potential hazards. Make sure to call all utilities (gas, electricity, etc.) before digging.

Figure 24 For your safety, make sure to contact local utilities before digging

Will I need to get my soil analyzed?

Water is heavy—1,000 L of water weighs 1,000 kg—therefore your cistern will require adequate structural support. Depending on the size and storage capacity of your cistern, local codes may require a soil analysis. This is to ensure that soils will be stable enough to support the weight of a full cistern and of additional snow loads (if applicable). For regions with heavy winds or prone to earthquakes, wind and seismic loads may need to be considered as well.

Are there any special access requirements?

Simple omissions, such as forgetting to measure the width of a doorway to ensure that your tank will fit through it, can cause a lot of frustration and cost you money. Before purchasing your system, ensure that there is enough space for each system component to be delivered and installed in its desired

location. For example, make sure that doorways, hallways and ceilings offer enough clearance (especially around corners) for components being carried and installed inside your home. Make sure there is a safe site access route for delivery trucks and large equipment such as excavators (for buried tanks) to work around your house.

If access is going to be an issue, you may have to modify your system (use smaller components), approach (craning the tank over obstacles), or plan for additional modifications or renovations (such as removing a fence or widening a doorway).

How do I ensure my tank remains securely in place?

Depending on local regulations, above-ground cisterns may be placed on a flat, level, concrete or compacted earthen or gravel base that will not erode during rainfall or be susceptible to frost heave. The base should be wide enough to support the cistern's entire bottom. In some municipalities, the tank base must be designed by a structural engineer.

The cistern should be adequately secured against falling over, whether it is located indoors or outdoors. Anchoring devices or ballasts are also required for below-ground cisterns to ensure that buoyancy doesn't push them to the surface.

What about health and safety?

As with any project, the health and safety implications of your rainwater harvesting system need to be addressed. In addition, because rainwater may not be as clean as drinking water, it is important to ensure that there is no potential for contamination of drinking water within the home, the well or the municipal system by your rainwater system.

Plumbing and electrical work

All plumbing, including the installation of backflow devices, and electrical work should be undertaken by certified plumbers and electricians, in accordance with local codes and regulations.

Proper labelling

The *2010 National Plumbing Code of Canada* requires that plumbing providing non-potable water within a residence be labelled. This is done using either purple piping or markings (labels) that indicate that the water is non-potable. This helps to ensure that plumbers, or do-it-yourself renovators, don't accidentally connect non-potable supplies to the potable plumbing supply at some point in the future. A cross-connection between potable and non-potable water systems could put your household and/or municipality at risk.

Figure 25 Typical marking for rainwater pressure piping

Maintaining Your System

Rainwater harvesting systems are not "fit-and-forget" type systems. They require ongoing monitoring and maintenance to protect against blockages, contamination and unwanted leaks and to ensure optimal performance.

Systems located in cold climates are also at risk of freezing and becoming damaged if not adequately protected or drained before winter sets in.

Good design and installation practices can help minimize maintenance needs:

- Trim overhanging tree branches to reduce leaf litter collecting in the eavestroughing.
- Do not collect rainwater from damaged catchment areas or areas close to air pollution sources.
- Ensure all piping and components of the system are properly sealed to keep groundwater and vermin out.
- Ensure the drainage system is designed properly to reduce the risk of leaks, spillage and flooding.

What regular maintenance does my system need?

Like your vehicle, your rainwater harvesting system benefits from a regular maintenance plan. Table 11 provides a general list of activities that will help keep your system in good working condition. Check with your system's designer or installer to determine specific maintenance requirements for your system.

Figure 26 To keep your system in good working order, it is important to regularly trim back overhanging trees and prevent debris from accumulating in eavestroughs and downspouts

Table 11 Inspection and maintenance activities schedule

Time frame	Activities
Every 3 months	■ Check condition of pre-filtration devices (gutter guards, first-flush diverters, etc.). Clean or replace as necessary. ■ Inspect disinfection filters and water quality treatment devices and systems. Ensure that they are operational and are maintaining minimum water quality requirements as determined by local authorities and in accordance with manufacturer's instructions.
Every 6 months	■ Inspect system for ponding. ■ Clear debris from roof, gutters, downspouts and gutter guards (if present). Clear any overhanging tree branches and foliage. ■ Check system for evidence of animal, bird or insect access (including mosquito larvae). If present, identify and close off access points. ■ Check for evidence of algal growth. If present, find and close off points of light entry. ■ Check tank and fittings for leaks and defects. Repair as necessary. ■ Ensure plumbing and pump connections are watertight. Repair as necessary.
Every 12 months	■ Check condition of roof and coatings. ■ Replace cartridges in water filters, UV lights on sterilizers, and chemicals or components in water treatment units strictly in accordance with manufacturer's instructions. ■ Inspect and verify operation of pumps, valves and pressure tanks. ■ Have a licensed plumber inspect backflow prevention devices and top-up system components as necessary and in accordance with local requirements. ■ Check for cross-connections by looking at visible plumbing fittings and alternately turning off supplies to ensure rainwater is not accidently being used for unauthorized purposes. ■ Check that access covers to storage tanks are closed and secured to prevent unauthorized entry. ■ Inspect caution label signage and pipe markings.
Every 3 to 5 years	■ Drain tank, check for deterioration and clean to remove accumulated sediment.

How can I fix common system problems?

A properly maintained system can work for years, however, as with most things, problems can occur from time to time. The following tables provide lists of common problems and potential solutions and can be used as a troubleshooting guide.

Table 12 Rainwater system troubleshooting guidance—water availability problems

Problem	Recommended actions / possible causes
Toilet not filling but other rainwater taps are working	■ Check toilet tank float and inlet valve for blockages or broken or inoperable components.
Water overflowing from pre-filter or first-flush diverter	■ Check if leaf screen is blocked, and clean as necessary. ■ Check tank inlet and outlet for blockages.
No water coming out of downspout into the leader heads	■ Check that downspout and gutter are not blocked, and clear as necessary.
No water coming out of taps when they are turned on	■ Check that pump and other system components are plugged in and that power is turned on. ■ Check electrical panel and reset breaker for the rainwater system. ■ Check water pipework from tank-to-pump and pump-to-fixtures for leaks. ■ Check tank water level (if water levels are too low, the pump may automatically turn itself off to prevent damage). ■ If trickle-feed municipal water backup is connected, wait 15 minutes for tank top-up and try again. ■ If trickle-feed supply is connected and no water is flowing into the tank, ensure municipal water supply is turned on. ■ If automatic switching device is fitted, ensure that municipal water supply is turned on and that solenoid valve is open/working.
Pump coming on when not using water	■ Check all taps and toilets connected to the tank for leaks. ■ Check pipes between pump and fixtures for leaks (even small leaks can cause a steady drop in water pressure, which requires the pump to cycle on frequently to keep up the pressure). ■ Remove control box lid and check fittings and hoses for leaks. ■ Check pressure tank for leaks.

Table 13 Rainwater system troubleshooting guidance—water quality problems

Problem	Recommended actions / possible causes
Dirty water in toilet or from taps	■ Clean pre-filtration devices. If not present, consider installing pre-filtration devices. ■ Check for broken pipes between house and tank. ■ Check tank water levels. Low water levels can cause high levels of tank sediment to be drawn into the rainwater supply. ■ Clean out the tank to reduce sediments or adjust the top-up system to increase tank water levels.
Sulphide, rotten egg or sewage odours	*This can be caused by anaerobic growth in accumulated sediment at the bottom of the tank. Water may be sitting in the tank for too long.* ■ Clean pre-filtration devices. If not present, consider installing pre-filtration devices. ■ Increase rainwater use to reduce time 'stale' water sits in the tank. ■ Install calming inlet. ■ Clean tank by removing sediment and/or disinfect tank with chlorine and flush chlorinated water through all pipework.
Slime and stagnant water in pipework	■ Avoid U-bends or underground pipework that can hold stagnant water. ■ Install drainage points on pipework to permit periodic draining.
Musty or vegetable type taste and odours (no light penetration)	*This can be caused by accumulated leaves in the gutter.* ■ Remove overhanging branches from trees. ■ Keep gutters clean. ■ Install gutter guards on eavestroughing or pre-filters on all downspouts connected to the rainwater harvesting system, if not present.
Musty vegetable or fishy type taste and odour (light penetration)	*This can be caused by algal growth due to light penetration into tank or pipework.* ■ Make sure tank is completely impervious to light. ■ Ensure pipework, including inlets to tanks, is impervious to light.
Coloured water, particularly after rain on tiled roof	*This can be caused by coloured particles of coating from roof shingles or tiles that are washed into tanks and re-suspended from sediments with fresh intake.* ■ Use colour-through tiles (colour is impregnated throughout the tile and is therefore more stable). ■ Remove sediment. ■ Install calming inlet

con't. **Table 13** Rainwater system troubleshooting guidance—water quality problems

Problem	Recommended actions / possible causes
Small white flakes in water	*This can be caused by microbial growth.* ■ Keep eavestroughs clean. ■ Install gutter guards on eavestroughing or pre-filtration devices on all downspouts connected to the rainwater harvesting system, if not present. ■ Install a post-storage treatment system to filter and disinfect rainwater, if not present. ■ Disinfect tank using chlorine.
Slime on inside of tanks	*This can be caused by microbial growth. All containers that continuously hold water will develop biofilm.* ■ This microbial growth is not problematic and can be left as is. However, if you wish, you can drain and clean the tank.

Costing Your System

Now that you have a good understanding of system requirements for size, design, installation and maintenance, it is time to consider costs. Depending upon the size of your rainwater harvesting system and its level of sophistication, costs can range from the hundreds to thousands of dollars. Exact costs will depend on the availability of materials and experienced labour.

How do I estimate the cost of my system?

When costing your system, you should budget for the all potential costs listed in worksheets 2 and 3. Use the worksheets to keep track of cost estimates provided by different suppliers. In general, if rainwater harvesting is an established practice in your area, there will be more suppliers and installers. In that case, rates will tend to be competitive. If the design and installation of rainwater harvesting systems is relatively new in your area, there will be fewer contractors and a limited number of systems being offered. Costs may tend to be higher. When possible, try to get quotes from three suppliers.

Worksheet 2 Rainwater harvesting system costing

	Estimated Cost		
	Supplier 1	Supplier 2	Supplier 3
Design and approvals **Subtotal**			
System sizing and design			
Eavestrough and downspout design and layout, if required			
Soils survey, if required			
Permit approvals			
Other:			
Components **Subtotal**			
Tank			
Tank base			
Pre-filtration devices (gutter guards, first-flush devices, etc.)			
Additional treatment systems, if required			
Conveyance and distribution systems (roof-to-tank and tank-to-fixtures plumbing fittings and piping)			
Pumps, pressure tank, electrical components, controls and wiring			
Top-up system—piping, valves, controls, backflow prevention			
Other:			
Installation costs **Subtotal**			

con't. **Worksheet 2** Rainwater harvesting system costing

		Estimated Cost		
		Supplier 1	Supplier 2	Supplier 3
Site work (such as excavation and restoration, landscaping), if required				
Plumbing work				
Electrical work				
Other:				
	Total cost			
Rebates, incentives or tax returns	**Applicable rebates**			
	Final cost			

Worksheet 3 Rainwater harvesting system operation and maintenance costs

	Estimated Cost		
	Supplier 1	Supplier 2	Supplier 3
Operation and maintenance			
Energy (for operating the pump and other electrical components)			
Maintenance			
Repair allowance (such as fixing a leaky tank)			
Water quality testing, if required			
Replenishment of treatment materials, if needed			
Inspection of rainwater system and/or plumbing, if required			
Other:			
Total cost			

How much should I expect to pay?

The following tables provide general information on average costs associated with basic rainwater harvesting system components. Costs will vary by region, availability of knowledge trades and construction market conditions. However, the following costs provide a rough order of magnitude of what you might expect to pay, for illustrative purposes only.

Rainwater storage tank

When selecting a tank, a general rule of thumb is that the cost per litre of storage gets cheaper as the tank size increases. As such, smaller tanks that are 2,000 L or less tend to have a higher cost per litre than larger tanks (greater than 10,000 L). For instance, if you are buying a 2,000-L above-ground plastic tank, you should expect your cost per litre to be toward the top end of the price range presented in table 14 (for an average cost of $860—2,000 L x $0.43).

Table 14 Estimated rainwater storage tank cost per litre (2012)

Tank type	Estimated Cost per Litre of Storage ($CAD)
Concrete (below-ground)	$0.30 to $0.45
Plastic (above-ground)	$0.23 to $0.43
Plastic (below-ground)	$0.25 to $0.49

Pre-filtration and post-storage treatment devices

The cost for downspout filters and first-flush devices, which are typically installed on each downspout, will vary from home to home, based upon the number of downspouts. Therefore, they are more economical for smaller homes with fewer downspouts. Similarly, the total cost of gutter guards will depend on the quantity and length of eavestroughs to cover. A pre-tank filter is another alternative that, while more expensive on a per-unit basis, may be cheaper for larger roof areas (these can typically handle up to a 300-m^2 roof catchment area each).

Post-storage treatment devices vary in price based upon the volume of water flowing through them. For a typical residential pump supplying 40 LPM (litres per minute), a simple particle filtration unit would cost around $38 (40 LPM x $0.94), whereas a unit that also has a UV lamp would cost around $376.

Table 15 Estimated cost of pre-filtration and post-storage treatment devices (2012)

Treatment type	Estimated cost
Gutter guards	$13 to $20 per metre of eavestroughing
Downspout filters and first-flush diverters	$100 to $370 per downspout
Pre-tank filters	$670 per filter
Particle filters	$0.77 to $0.94 per pump LPM
Particle filters and UV lamps	$4.65 to $9.40 per pump LPM

Pump and electrical components

Pump costs vary widely based upon a variety of factors, including:

- the pump type (submersible, jet pump located outside of the rainwater tank, etc.);
- the motor configuration;
- the pump flow rate;
- the pressure (or "head") that must be produced to supply rainwater at the correct pressure to the end uses; and
- the manufacturer of the unit.

Based upon these factors, it can be difficult to estimate the cost of a pump for a particular system. Most pumps would fall into a range of $16 to $26 per LPM supplied by the pump. In this range, the cost for a 40-LPM pump would be between $640 and $1,040.

Table 16 Pump and related component costs

Component	Cost
Pump and pressure tank	$16 to $26 per LPM
Float switch	$57 to $103 each
Solenoid valve	$158 to $328 each

EXAMPLE Cost estimate of a complex rainwater harvesting system

To provide you with an idea of the cost of a complex rainwater harvesting system, here is a cost estimate for a system serving a three-person household in Guelph that supplies rainwater for year-round toilet flushing and outdoor uses. The calculation was done using an online tool called the *Rainwater Harvesting Design and Costing Tool*.[8]

The system had the following components:

- a 100-m² catchment area (roof with asphalt shingles);
- a 5,000-L below-ground pre-cast concrete storage tank;
- a 40-LPM pump;
- a top-up system (with the required electrical accessories, solenoid valve and float switch);
- a pre-filtration system (with one leaf screen); and
- typical conveyance and distribution piping from a buried tank into the home and within the home.

Given these characteristics, the following estimate was generated for this system:

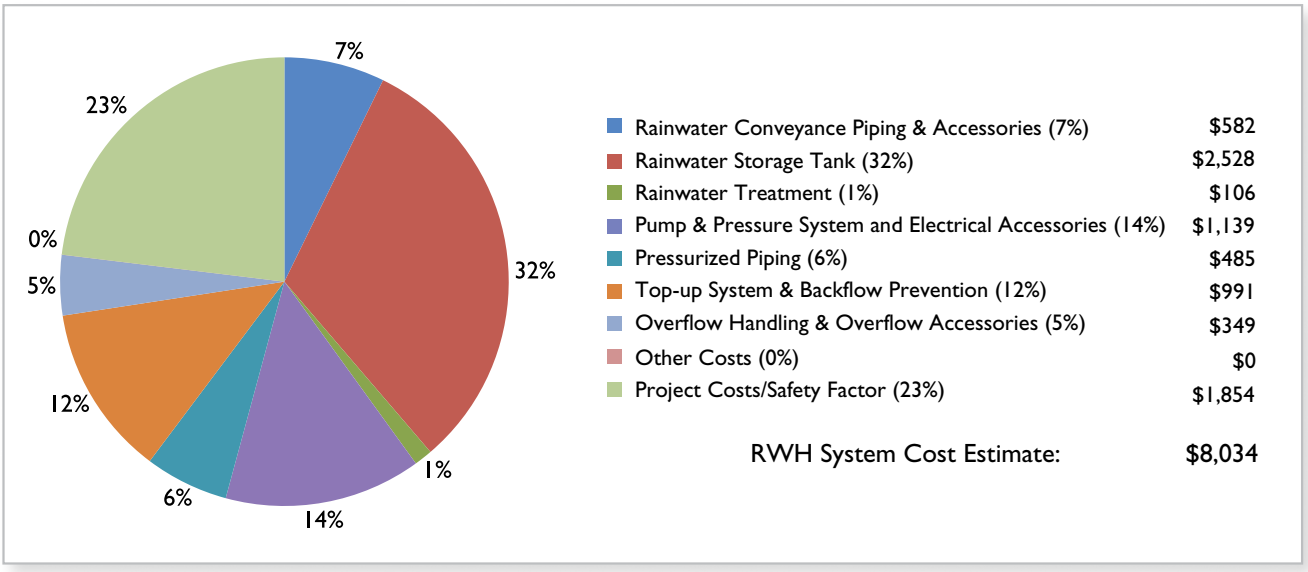

Figure 27 Estimated cost of a complex rainwater harvesting system

The total estimated cost for this complex rainwater harvesting system is around $8,000 once engineering design costs (listed as "Project Costs" above), material costs and installation costs (which were factored in with the various material costs) are included. As shown above, the costs associated with the storage tank (tank and excavation costs) are the largest. Engineering fees and pump-related expenses (pressure system and electrical components) account for the second and third largest shares of the cost, respectively.

[8] Developed by the Sustainable Technologies Evaluation Program (STEP), a multi-agency initiative led by the Toronto and Region Conservation Authority, this tool aims to assist with the design, sizing and costing of residential- and commercial-scale rainwater harvesting systems in Southern Ontario. It is available online on STEP's website at http://sustainabletechnologies.ca/wp/clean-water/stormwater-management/rainwater-harvesting/rainwater-harvesting-design-and-costing-tool/ Accessed October 19, 2012.

Regional cost variations

In some areas where there is an established market for rainwater harvesting systems, it may be possible to have a supplier and/or plumber install an 'all-in-one' system. In this case, you may be able to avoid having to hire an engineer to custom-design a system for your home, which can provide significant cost savings.

The cost of a rainwater harvesting system will also vary based upon the regional cost of materials and labour. To provide a rough estimate of how the cost of the same system from our example varies across Canada, different markets were also analyzed. The results are summarized in table 17.

Table 17 Regional cost comparison for a complex rainwater harvesting system

	Ontario	Alberta	British Columbia	Nova Scotia
Estimated system cost	$8,034	$8,028	$7,838	$6,483

Since many of the components of a rainwater harvesting system (piping, pumps, etc.) are priced nationally and do not change significantly from province to province, the price of a rainwater harvesting system does not vary widely across the country. One exception is Nova Scotia, where the cost was found to be slightly lower thanks to lower labour costs.

Conclusion

The rewards of rainwater harvesting can be significant. Despite living in a seemingly water-rich country, Canadians are aware of the value of clean drinking water and of the need to conserve it. Using treated potable water in toilets and for landscape irrigation does not make sense to many. In comparison, rainwater use, where permitted and practical, can help us reduce our carbon footprint by reducing the need for energy for the treatment and delivery of municipal water to our homes.

Storing and using rainwater takes some of the pressure off municipal storm drains and can help prevent flooding. In times of drought, the stored water allows property owners more leeway in water use than homes and businesses relying on municipal water for irrigation. Plus, it saves money.

Installing a rainwater harvesting system can be a significant investment and must be carefully done to ensure the system operates safely and efficiently. Unless you are a building contractor, plumber and electrician, you will need to consult with professionals for all or parts of the installation. Even a gifted do-it-yourself builder should consult a rainwater harvesting specialist and, depending on the size of the tank and the regional geography, other specialists may be needed.

Tools and Additional Resources

Rainwater harvesting system planning checklist

The following checklist is designed to help you ensure that your system is designed properly. Whether you are managing the project yourself, or working with a contractor, you can use this checklist to verify that all key steps are completed and to keep track of your progress.

Worksheet 4 Rainwater harvesting system planning checklist

✓	Key questions and actions	Notes and answers
	What building permits and/or plumbing approvals are required in your municipality?	
	Consult local municipality.	
	Apply for the necessary permits.	
	Have the system inspected at the appropriate times and secure final approval of the system by the necessary authorities prior to use.	
	Are there any rebates or incentive programs available from the provincial government or local municipality for rainwater harvesting, water conservation and/or stormwater management?	
	Look up rebate programs.	
	Try to ensure that your rainwater harvesting system meets the program criteria (if possible) and apply for the applicable rebates.	

con't **Worksheet 4** Rainwater harvesting system planning checklist

✓	Key questions and actions	Notes and answers
	What parties are needed to design and install the system (for example, is an engineer required, or can a plumber or rainwater system supplier submit plans for approval)?	
	Consult local municipality.	
	Determine how much of the work you are willing and able to do yourself and what professional help you will need.	
	Hire the necessary parties to design and install a safe and effective system for your home.	
	Is the rainwater being harvested for indoor use, outdoor use or both?	
	Determine which uses are permitted within your jurisdiction.	
	Determine if there are any treatment requirements for these uses.	
	Pick the permitted uses that best suit your needs and the type of treatment system you feel comfortable managing.	
	What is your annual water consumption for the permitted uses you plan on supplying with the rainwater system?	
	Calculate average usage using worksheet 1.	
	How much rainwater can be collected in your area based on local precipitation patterns and your roof size?	
	Annual rainfall (in millimetres) times the area of catchment (in square metres) equals the maximum theoretical number of litres that can be captured. Reduce this value by 20 per cent to get a more accurate value, based upon typical losses from roofs, gutters and pre-filters.	
	Tanks vary based upon material, location (above or below ground) and size. Given these factors, what type of tank is best suited to the site and purpose, and does it comply with the relevant Canadian standards?	
	Consult an expert (such as an engineer or tank supplier).	
	What type of preparation is needed for the selected type of tank? For example, for above-ground tanks, what type of tank stand or base has been agreed upon, or for below-ground tanks, what are the excavation and base requirements?	
	Consult an expert (such as a soils or structural engineer or tank supplier).	
	Get soil tested and/or land surveyed, if necessary.	

con't **Worksheet 4** Rainwater harvesting system planning checklist

✓	Key questions and actions	Notes and answers
	For above-ground or elevated tanks, do the proposed construction materials meet durability standards given the soil type and weather (for instance, high winds) at the site?	
	Consult tank supplier for installation instructions.	
	Consult an expert (such as a contractor).	
	Are there any restrictions that prevent heavy equipment from accessing the location where the tank or other components are planned to be installed?	
	Consult an expert (such as a contractor).	
	Are any services such as plumbing and irrigation pipes, gas lines, electrical and telephone cables or underground taps and switches likely to be affected or concealed by the proposed installations?	
	Call utilities before digging.	
	If retrofitting an older home, are the construction and materials used on the existing roof, eavestroughs and downspouts suitable for use in a rainwater collection system, or is some remedial work required?	
	Consult an expert (such as an engineer or eavestroughing contractor).	
	Will the type of pump selected provide sufficient pressure and flow rates to the fixtures connected to the rainwater harvesting system?	
	Consult an expert (such as a mechanical engineer, plumber or pump supplier).	
	How will the pump be powered? Can it simply be 'plugged in,' or does it have to be hard-wired into the electrical supply panel for the house?	
	Consult an expert (such as a mechanical engineer, plumber, electrician or pump supplier).	
	Is the pump located in an area with adequate ventilation and protection from weather and flooding, and capable of meeting the local noise requirements?	
	Consult an expert (such as a mechanical engineer, plumber or pump supplier).	
	Consult municipality.	
	What effect will the tank, stand and pump have on the general amenity and enjoyment of the home and those of the neighbours?	
	Talk to your neighbours first, if applicable.	

con't **Worksheet 4** Rainwater harvesting system planning checklist

✓	Key questions and actions	Notes and answers
	What type of filter system (if any) will be used and what effect will this have on the pressure and flow rates?	
	Consult an expert (such as a mechanical engineer, plumber, electrician or pump supplier).	
	Is a municipal water supply top-up required and if so will it be provided with an automatic switching device or a trickle-feed system?	
	Consult local regulations and your contractor.	
	Are the eavestroughs draining appropriately to downspouts that will feed the tank? If not, does the quote allow reinstalling the eavestroughs or installing additional downspouts?	
	Consult an expert (such as a rainwater harvesting system designer or eavestroughing contractor).	
	Obtain quotes from three eavestroughing contractors, if necessary.	
	What type of first-flush diverter will be installed—one on each down pipe, or one on or in the tank?	
	Consult an expert to see which options are best for you.	
	Will the proposed installations have an effect on the footings of the home and, if so, what can be done about this and has it been allowed for?	
	Consult an expert (such as a structural engineer or contractor).	
	If the tank is to be installed below ground, have the effects of potential hydrostatic lift been considered and compensated for?	
	Consult a soils expert (such as an engineer).	
	Has an appropriate overflow system been designed for the installation? Is the overflow directed to a rain garden or storm sewer as per local approvals?	
	Consult an expert.	
	Consult municipality officials.	
	Do the contractor(s) and property owner understand and agree with all the provisions of the contract?	
	Make sure contracts are written for all work to be done.	
	Review contracts carefully and make sure all parties agree to the contract. Make sure changes requested to the contract are made before you sign.	

con't **Worksheet 4** Rainwater harvesting system planning checklist

✓	Key questions and actions	Notes and answers
	Have you discussed the proposed installation with your insurance agent and ensured that it will be covered?	
	Contact your insurance provider.	
	Ensure your installation meets your insurance provider's requirements.	

Glossary of terms

Air gap—the vertical distance between the lowest point of a water supply inlet and the flood level rim of the fixture or device into which the inlet discharges (see text box on page 26).

Backflow—the flow of water or other liquids, mixtures or substances in the wrong direction into the distributing pipes of a supply of potable water that may make the water in the pipe non-potable (may result from a differential pressure existing between two systems).

Calming inlet—a device that permits water to enter a storage tank with minimal disturbance to particles that may have settled to the bottom of the tank.

Catchment area—the area (usually the rooftop) from which the rainwater will be captured.

Cistern—a reservoir (below- or above-ground) for storing water (also known as a tank).

Conveyance system—the collection of piping (eavestroughs, downspouts, etc.) that moves water from the roof to the storage tank.

Desalination—the process of removing salt from water.

Disinfection—the process of removing pathogenic microbes.

Distribution system—the collection of plumbing pipes that move rainwater from the storage tank to the fixtures where it will be used.

Downspout—a pipe that carries water from an eavestrough to the ground, storm drainage system or rainwater harvesting system.

Drinking water—water that is suitable for human consumption, food preparation, utensil washing and oral hygiene (also called potable water).

Eave—the part of a roof that projects beyond the face of a wall.

Eavestrough—a trough fixed to an eave to collect and carry away (usually via a downspout) the runoff from the roof (also called gutter).

Filtration—the process of removing particulates from a medium (such as water).

First-flush diverter—a device that diverts the first portion of water from the catchment area that carries the most contaminants (dust, leaves, animal droppings, etc.).

Fixture—a receptacle, appliance, apparatus or device in a plumbing system that may discharge sewage or clear wastewater (toilet, laundry machine, sink, etc.).

Flashing—sheet metal or other material used in roof and wall construction to shed water.

Flow rate—the volume of fluid (water) that passes through a fixture over a specific period of time.

Frost line—the depth at which groundwater in the soil is expected to freeze.

Greywater—wastewater from household baths and showers, laundry appliances and sinks, but excluding wastewater and excreta from toilets and urinals.

Groundwater—free subsurface water, the top of which is the water table.

Gutter—a trough fixed to an eave to collect and carry away (usually via a downspout) the runoff from the roof (also called eavestrough).

Irrigation—the artificial application of water to land or soil.

Leader—a pipe that is installed to carry stormwater from a roof to a building storm drain or sewer or other place of disposal.

Municipal water—the water that is provided by a municipally managed water supply system and that is suitable for drinking.

Overflow—the surplus of water that cannot be contained in the available space (eavestroughs, tanks).

Piping system—a network of pipes that carries water from the source (such as a rainwater cistern or water main) to where it will be used (for example, tap, toilet, irrigation system).

Point of use—the area where the water will be used (for example, tap, toilet, irrigation system).

Ponding—the unwanted pooling of water (on a roof, for example).

Potable water—water that is safe for human consumption; water that is drinkable (also called drinking water).

Rain barrel—the simplest form of rainwater harvesting, that is, a barrel placed underneath a downspout to store rainwater with a spout to deliver rainwater by gravity flow.

Runoff—excess surface water that flows over a site instead of percolating through the soil.

Scale buildup—the accumulation of naturally occurring compounds on surfaces.

Screen—a mesh that allows water or air to flow, but prevents leaves, twigs, insects and small animals from entering the rainwater harvesting system.

Sedimentation—the tendency for particles suspended in a liquid to settle; the resulting sediment accumulates at the bottom of storage tank.

Setback—the distance a structure must be from other elements such as a road, building or river.

Storm sewer—the part of storm drainage piping outside a building that connects the building storm drain to the main storm sewer; it starts at a point 900 mm from the outer face of the wall of the building and terminates at the property line or place of disposal on the property.

Subsurface irrigation—a system for watering lawns, gardens or fields below the surface, at root level.

Surface irrigation—a system for watering lawns, gardens or fields by spraying or trickling water from above the surface.

Surface water—the water that collects or flows on the surface, such as ponds, lakes, streams, etc.

Tank—a reservoir (below- or above-ground) for storing potable water (also known as a cistern).

Top-up system—a system that tops up the rainwater storage tank with well or municipal water when there is insufficient rainwater, typically via an air gap.

Water metering—the process of measuring water use with water meters.

Relevant CMHC publications

CMHC publishes a range of information on sustainable housing. In addition to the publications listed below, valuable information is available on our website at www.cmhc.ca.

About Your House fact sheets are intended to assist homeowners in taking appropriate measures to address existing problems in their house or to make informed decisions about changes or upgrades they may be planning. These fact sheets are available free of charge.

Selected titles:

- *Buying a Water-Efficient Toilet* (product no. 62935)
- *Low-Maintenance Lawns* (product no. 63488)
- *Rain Gardens: Improve Stormwater Management in Your Yard* (product no. 63490)
- *Water-Saving Tips for Your Lawn and Garden* (product no. 62042)

Other free publications, selected titles:

- *EQuilibrium™ Housing InSight: EchoHaven Water Conservation Measures* (product no. 67655)
- *Guidelines for Residential Rainwater Harvesting Systems Handbook* (product no. 67608)

Priced publications, selected titles:

- *Landscape Guide for Canadian Homes* (product no. 63523)
- *Household Guide to Water Efficiency* (product no. 61924)

Visit our website at www.cmhc.ca to download these publications.

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Guidelines for Residential Rainwater Harvesting Systems Handbook

Product No. 67608

Want to know more about rainwater harvesting systems?

The most important considerations when designing and installing a rainwater harvesting system are the pertinent provincial codes and regulations, standards and municipal bylaws. Other considerations include the way in which the design, installation and management of rainwater harvesting systems can affect the quantity of water saved and the quality of rainwater harvested, as well as the 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:

- Rainwater catchment and conveyance
- Rainwater storage and tank sizing
- Rainwater quality and treatment
- Make-up water system and backflow prevention
- Pump and pressurized distribution system
- Overflow provisions and stormwater management

This document is aimed at a wide audience, including homeowners, engineers, architects, contractors, developers, regulators, as well as members from municipal, provincial and federal levels of government. Background information on each aspect of a rainwater harvesting system is discussed, and 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.

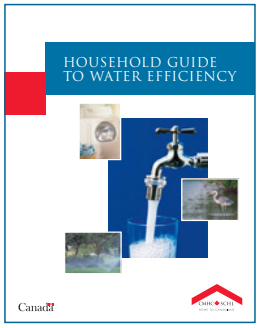
To download a copy of this Handbook, visit our website at www.cmhc.ca.

Rainwater Harvesting

A Guide for Homeowners

About Your House Fact Sheets

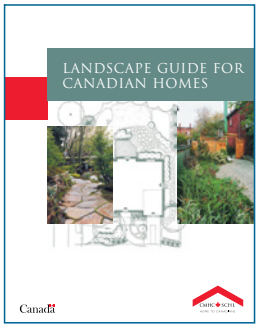
About Your House fact sheets are intended to assist homeowners in taking appropriate measures to address existing problems in their house or to make informed decisions about changes or upgrades they may be planning. Titles include *Buying a Water-Efficient Toilet* (product no. 62935), *Low-Maintenance Lawns* (product no. 63488), *Rain Gardens: Improve Stormwater Management in Your Yard* (product no. 63490) and *Water-Saving Tips for Your Lawn and Garden* (product no. 62042).



Household Guide to Water Efficiency

A national publication for residential consumers, this user-friendly Guide provides information on water-efficient fixtures and appliances, and shows how to test for and repair leaks, make the most efficient use of water when doing daily chores, and plan residential landscapes with water efficiency in mind.

Product no. 61924



Landscape Guide for Canadian Homes

Meet your home landscaping needs while respecting the natural environment, whether you want a radical makeover or want to spruce up an old garden. Illustrated with many colour photos and drawings, the Guide describes the design process, materials, types of plants, soils and so much more. Learn about low-maintenance gardens and lawns, water conservation, natural pest control methods, and how to hire a landscape contractor.

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