Block D: Drainage Systems

TRU Open Press

Plumbing Apprenticeship Program Level 2 Series

Block D: Drainage Systems

BC Plumbing Apprenticeship, Level 2

SKILLED TRADES BC

BC PIPING ARTICULATION AND CURRICULUM SUBCOMMITTEE; ROD LIDSTONE; AUDREY CURRAN; AND PAUL SIMPSON

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In the field, there are many similarities or overlaps with the work of plumbers and gas fitters. Many plumbing and heating contractors employ both plumbers and gas fitters as well as tradespeople with dual certifications.

Upon completion of a Plumbing Apprenticeship, a plumber can receive cross-program credit for a portion of the Gas fitter apprenticeship. As such, training in fuel gas has been incorporated into all levels of the Plumbing Apprenticeship.

Block D of the **Plumbing Apprenticeship Program Level 2 Series** focuses on the fundamentals of sanitary and storm drainage systems, providing apprentices with a comprehensive understanding of installation, maintenance, and repair processes. This section equips apprentices with essential skills to handle the complexities of both sanitary and storm drainage systems, ensuring effective installation and upkeep in various settings.

Plumbing Apprenticeship Program Level 2 Series

The *Plumbing Apprenticeship Program Level 2 Series* offers comprehensive training materials designed to build on foundational skills and knowledge. The series is divided into four main blocks, each focusing on critical areas of plumbing systems and installations.

Block A: Fuel Gas Systems (https://a-fuelgas-bcplumbingapprl2.pressbooks.tru.ca/)

A-1: Gas Fired Appliances
A-2: Gas Codes Regulations and Standards
A-3: Gas Appliance and Building Air Requirements
A-4: Technical Instruments and Testers

Block B: Heating and Cooling Systems (https://b-heating-bcplumbingapprl2.pressbooks.tru.ca/)

B-1: Types of Heating and Cooling Systems
B-2: Hydronic Heating and Cooling Generating Equipment
B-3: Hydronic Heat Transfer Units
B-4: Hydronic Heating Piping and Components

Block C: Install Fixtures and Appliances (https://c-plumbfixappliance-bcplumbingapprl2.pressbooks.tru.ca/)

C-1: Plumbing Fixtures and Trim
C-2: Plumbing Appliances

Block D: Drainage Systems (https://d-drainagesystems-bcplumbingapprl2.pressbooks.tru.ca/)

D-1: Sanitary Drain, Waste and Vent Systems
D-2: Planning and Installation of DWV Systems
D-3: Storm Drainage Systems
D-4: Test and Drainage Systems
D-5: Drainage System Maintenance and Repairs

Plumbing Apprenticeship Program Overview and Upcoming Resources

- **Plumbing Apprenticeship Program Level 1 Series** is coming soon to TRU Open Press in 2025–2026!
- **Plumbing Apprenticeship Program Level 3 Series (https://collection.bccampus.ca/search/?q=%22pl3%22)** can be found in the BCCampus Open Collection (https://collection.bccampus.ca/).
- **Plumbing Apprenticeship Program Level 4 Series** (https://bccampus.ca/projects/archives/zed-cred-z-degrees/ztc-open-educational-resources-for-trades/) can be found in the BCCampus Open Collection. (https://collection.bccampus.ca/) (Block F: Commission and Service will be available soon.)

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Safety Advisory

The current Standards and Regulation in BC can be obtained at the WorkSafeBC (http://www.worksafebc.com) website: http://www.worksafebc.com

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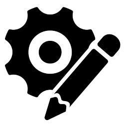	Required or Optional Resources
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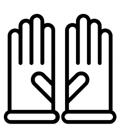
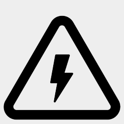
	Use Protective Equipment
	Potential Electric Shock

Acknowledgments

The development of the *Piping Trades Learning Guides* was a collaborative effort driven by a commitment to excellence in trades education. These guides were created to support apprentices and journeypersons in mastering the skills and knowledge essential to the piping trades. This achievement would not have been possible without the dedication and expertise of *Skilled Trades BC* and the *Piping Trades Articulation Committee*, whose leadership and guidance have been instrumental in shaping high-quality training resources. We extend our sincere gratitude for their contributions and ongoing stewardship in advancing the piping trades.

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The Open Press combines TRU's open platforms and expertise in learning design and open resource development to support the creation and reuse of open educational resources, while encouraging open scholarship and research.

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SkilledTradesBC. (2022, December 1). Introducing Skilled Trades BC. YouTube. https://www.youtube.com/watch?v=OQgwdP0rNog

Trades Training BC. (2021). A-1: Introduction to gas-fired appliances. In: *Plumber Apprenticeship Program: Level* 2. Industry Training Authority, BC.

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D-3 INSTALL STORM DRAINAGE SYSTEMS

Plumber Apprenticeship Program – Level 2

D-3 Storm Drainage Systems Introduction

Storm drainage systems collect and transport rainwater to municipal or home collection locations for recycling or dispersing back into the water cycle.

Learning Objectives

After completing the chapters in this section, you should be able to:

- Describe the terminology and functions of a storm drainage system
- Describe code requirements for a storm drainage system
- Describe the planning of layouts for a storm drainage system
- Describe the installation of storm drainage systems

Resources

You will be required to reference the most current National Plumbing Code.

Terminology

The following terms will be used throughout this section. A complete list of terms for this section can be found in the **Glossary**.

Please also see the separate list of NPC Definitions for DWV Systems in Section D-3.1.

- **15-minute rain event:** A standard time frame used to express storm drainage load calculations, based on the volume of rainfall (in litres) expected over a 15-minute period. This metric helps determine appropriate pipe sizing. (Section D-3.3)
- **berm**: A raised area of soil that is typically built along the edge of a trench or drain to hold back water, directing it into the drain for proper collection and drainage. (Section D-3.7)
- **catch basin:** A ground-level stormwater collection point, often found in paved areas, that traps debris like

leaves before directing rainwater or stormwater into pipes for proper drainage. It has a grate on top to catch debris and prevent blockages, helping direct the water into storm sewers for discharge into natural water bodies. (Section D-3.2; Section D-3.6)

- **clamping collar**: A metal ring used to hold parts together, like a roof drain and the waterproof membrane, to make sure everything stays tightly in place and doesn't let water leak through. (Section D-3.5)
- **combined drainage piping system:** A system that carries both stormwater and wastewater in the same pipe. These systems can overflow during heavy precipitation, leading to direct discharge of untreated water into natural water bodies. (Section D-3.2)
- **corrugated steel galvanized pipe:** A type of durable, ribbed metal piping commonly used in stormwater systems such as culverts or detention systems. It must be joined with couplings that align pipes, resist separation, and prevent root or debris infiltration. (Section D-3.3)
- **curtain drain**: A French drain installed across a slope to intercept and drain water away from sensitive areas, such as septic disposal fields, reducing water accumulation and lowering the water table. (Section D-3.7)
- **deck drain:** A flat-strainer drain used in areas like walkways or patios, similar to a roof drain but intended for horizontal surfaces other than roofs. (Section D-3.2)
- **drainage trough:** A narrow channel or trench that collects and moves water away from areas like driveways or parking lots. Made of concrete or plastic, it has a grate on top for water to flow into, helping keep the area dry and safe. (Figure 4, Section D-3.6)
- **drain tile**: A type of pipe used in drainage systems, often made of clay, that helps collect and move water from the soil, typically used around foundations. (Section D-3.7)
- **duplex system:** Two pumps in a sump, each with its own pipes and valves. Float switches inside the sump detect water levels, and a control panel automatically turns the pumps on or off. This setup ensures the system works even if one pump fails. (Section D-3.6)
- **fixture unit (FU):** A unit of measure used in sanitary drainage systems to represent the load-producing effect of a plumbing fixture. In combined systems, 1 FU = 9.1 L/15 min when total load exceeds 260 FUs. (Section D-3.3)
- **float switch:** A device that controls water levels in tanks or pumps. It has a floating part that moves with the water level, and when the water gets too high or low, it sends a signal to turn the pump on or off to keep the water at the right level. (Section D-3.6)
- **flow-control roof drain:** A roof drain designed to limit the rate at which stormwater is released into the drainage system, reducing pipe size and minimizing strain on municipal sewers during peak rainfall. Design requirements include placement limits and overflow protection. (Section D-3.2)
- **French drain**: A drainage system consisting of a trench filled with perforated pipe and clean rock, designed to direct surface water away from an area. (Section D-3.7)
- **green roof:** A rooftop covered with vegetation that absorbs rainwater, reducing runoff and providing benefits like energy efficiency and improved air quality. (Figure 5, Section D-3.8)
- **greywater:** Water that comes from sinks, showers, and washing machines in your home. It's not dirty like sewage water, but it's not clean enough to drink either. Greywater can be reused for things like watering plants or flushing toilets to help save fresh water. (Section D-3.8)
- **hydrology**: The scientific study of the movement, distribution, and management of water, including the water cycle and water resources. (Section D-3.7)
- **litres per 15 minutes (L/15 min):** The unit used to express drainage loads in storm and combined systems, aligning volume with a 15-minute rainfall time frame. Helps convert area and rainfall depth into actionable flow data. (Section D-3.3)

- **local rainfall intensity:** The amount of rain, measured in millimetres, expected to fall over a 15-minute period in a specific geographic location. This data is obtained from the National Building Code and is critical to calculating drainage loads. (Section D-3.3)
- **minimum slope**: The smallest allowable incline for drainage pipes, typically 1:50 as per regulations like the NPC. In some cases, the slope may be reduced to 1:100 for building drains at least 100 mm (4 in.) in size to match other connected drainage systems. (Section D-3.5)
- **moling**: A process in agriculture where a torpedo-shaped mandrel creates tunnels or voids in the soil without leaving a visible trench, often used to improve drainage in waterlogged fields. (Section D-3.7)
- **rainwater leader (RWL):** A vertical pipe or tubing that conveys rainwater from roof drains or gutters to the ground or stormwater disposal system. Can be installed inside or outside a building. (Section D-3.2)
- **Roof scupper (or scupper):** An exterior, box-like device or opening in a parapet or wall that collects and drains stormwater from flat roofs. Scuppers serve as emergency overflow systems to prevent water buildup when primary roof drains are blocked. They are often used in combination with parapet walls and flow-control drains. Scuppers must be located no more than 30 m (100 ft) apart and be capable of handling up to 200% of local rainfall intensity when used with flow-control systems. (Section D-3.3)
- **sheet metal leader:** A vertical exterior pipe made of sheet metal that conveys rainwater from gutters to the ground. It is permitted for use only above ground and outside a building. (Section D-3.3)
- **siphonic roof drain:** A high-capacity roof drain that uses siphonic action to drain water more quickly than traditional gravity drains, reducing the number of required drains. (Section D-3.2)
- **sub-drainage system:** (subsoil drainage system); A network of pipes or drains placed underground to collect and carry away excess water from the soil. It helps prevent flooding or water buildup by directing water to safe areas, keeping the ground dry and stable. (Section D-3.6)
- **trenchless plow**: A type of equipment used in moling that creates a narrow void or tunnel in the soil without disturbing the surface or creating a visible trench. (Section D-3.7)
- **vitreous clay pipe**: A type of pipe made from baked clay that has a smooth, hard surface, like glass. It's used in plumbing and drainage systems because it's strong, durable, and resists wear and tear from water and chemicals. (Section D-3.7)

D-3.1 Storm Drainage Terminology

Terminology

This chapter introduces the terminology used when interpreting the code regulations for storm water drainage systems in buildings. Because the terminology and sizing techniques are quite different from sanitary drainage, the ability to interpret the National Plumbing Code (NPC) is vital.

NPC Definitions for DWV Systems

Much of the terminology associated with storm drainage systems is provided in the NPC.

authority having jurisdiction (AHJ): the governmental body responsible for enforcing any part of the British Columbia Plumbing Code.

clearwater waste: wastewater with impurity levels that will not be harmful to health and may include cooling water and condensate drainage from refrigeration and air-conditioning equipment and cooled condensate from steam heating systems but does not include storm water.

combined building drain: a building drain intended to conduct sewage and storm water.

combined building sewer: a building sewer intended to conduct sewage and storm water.

combined sewer: a sewer intended to conduct sewage and stormwater.

leader (rainwater leader or RWL): a pipe installed to carry stormwater from a roof to a storm building drain, sewer, or other place of disposal.

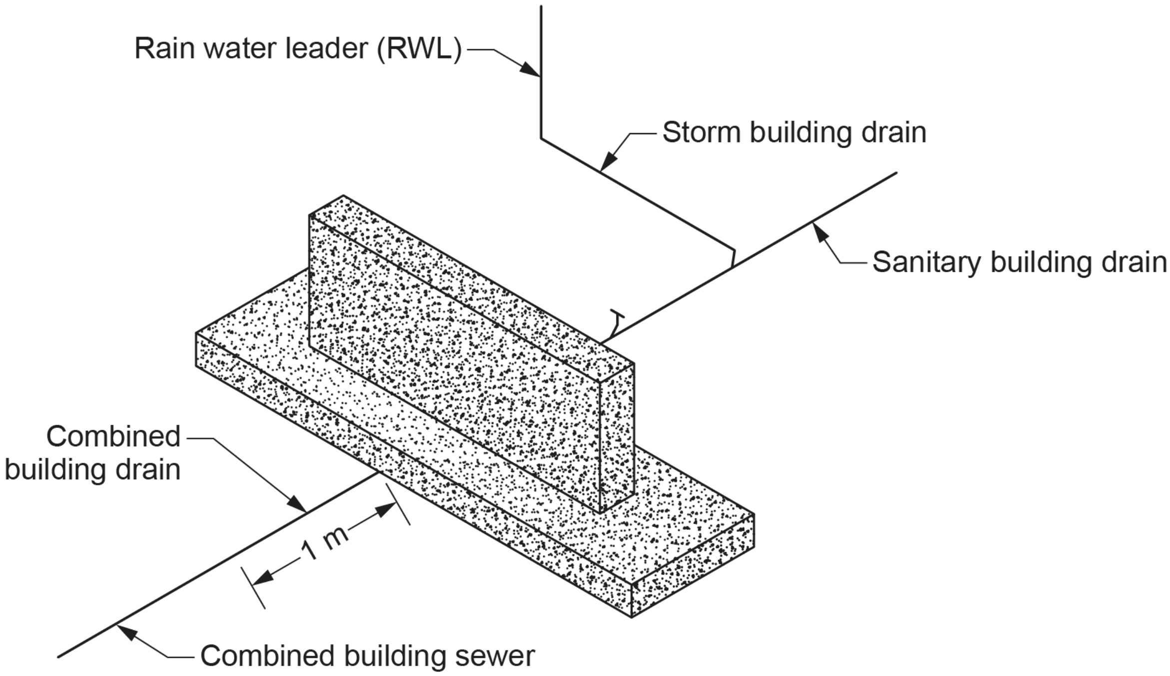

***Figure 1** Combined drainage terminology. (Skilled Trades BC, 2021) Used with permission.*

rainfall intensity: the quantity of rainfall related to a unit of time. For the purposes of the NPC, rainfall intensity is expressed in mm/15 min.

roof drain: a fitting or device installed in the roof to allow stormwater to discharge into a leader (Figure 2).

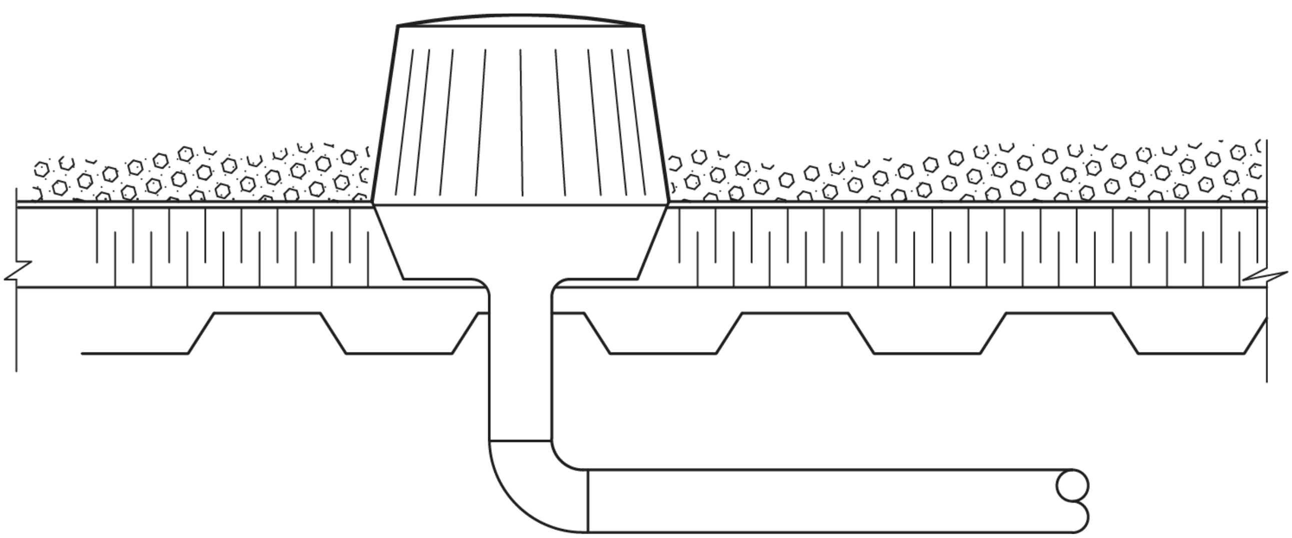

***Figure 2** Roof drain serving flat surface. (Skilled Trades BC, 2021) Used with permission.*

Roof gutter: an exterior channel installed at the base of a sloped roof to convey stormwater (Figure 3).

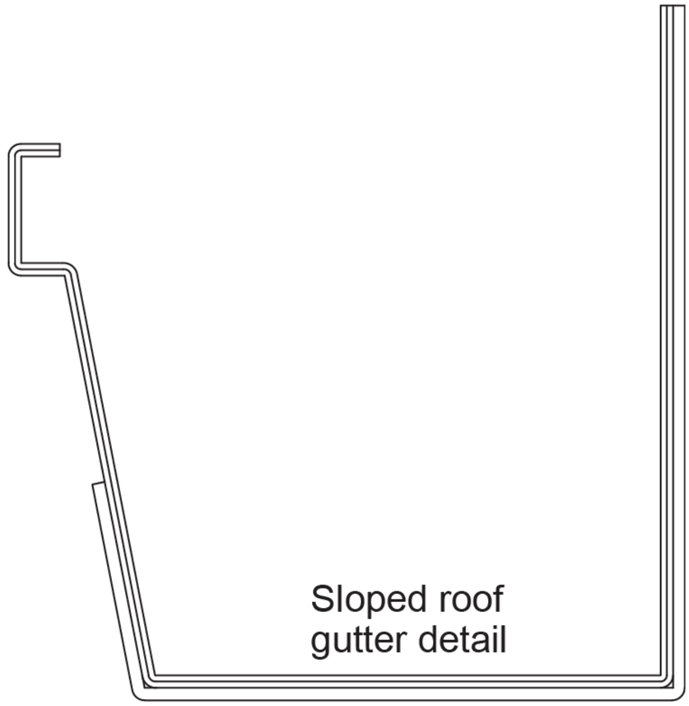

Figure 3 *Roof gutter serving sloped surface. (Skilled Trades BC, 2021) Used with permission.*

storm building drain: a building drain that conducts storm water and is connected at its upstream end to a leader, sump, or catch basin and at its downstream end to a building sewer or a designated stormwater disposal location.

storm building sewer: a building sewer that conveys stormwater.

storm drainage system: a drainage system that conveys stormwater.

storm sewer: a sewer that conveys stormwater.

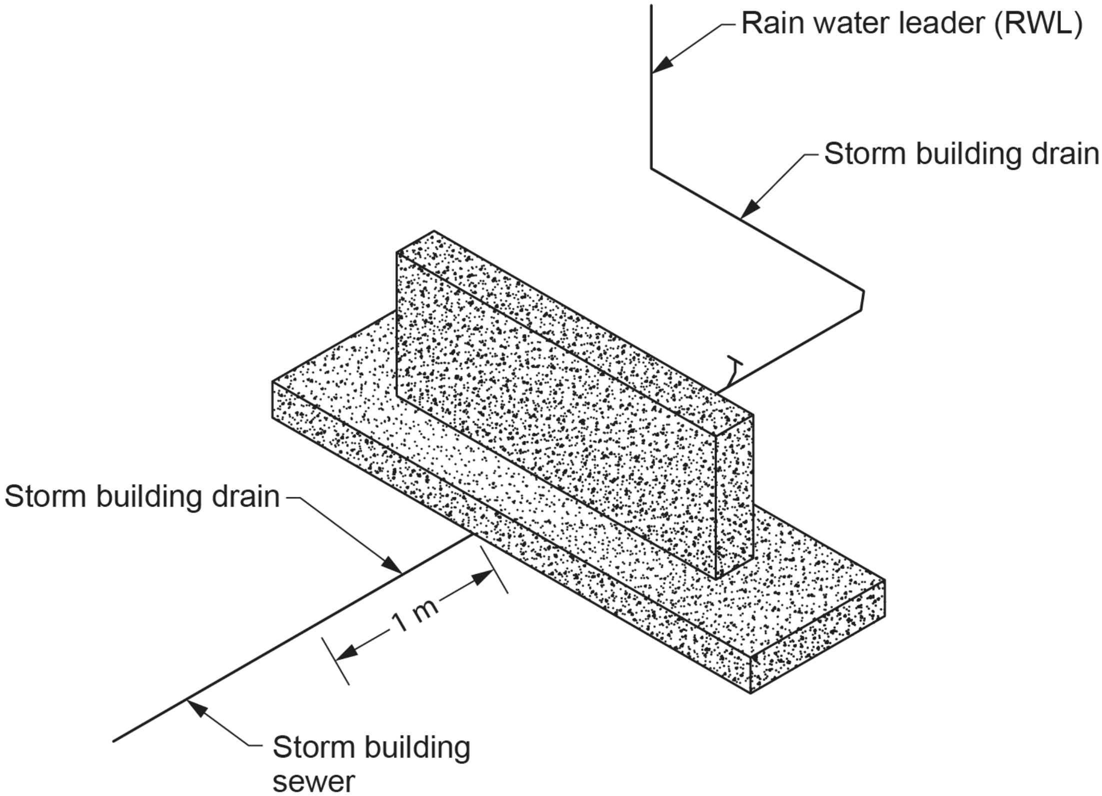

Figure 4 *Storm drainage terminology. (Skilled Trades BC, 2021) Used with permission.*

stormwater: water discharged from a surface as a result of rainfall or snowfall.

subsoil drainage pipe: a pipe installed underground to intercept and convey subsurface water (Figure 5).

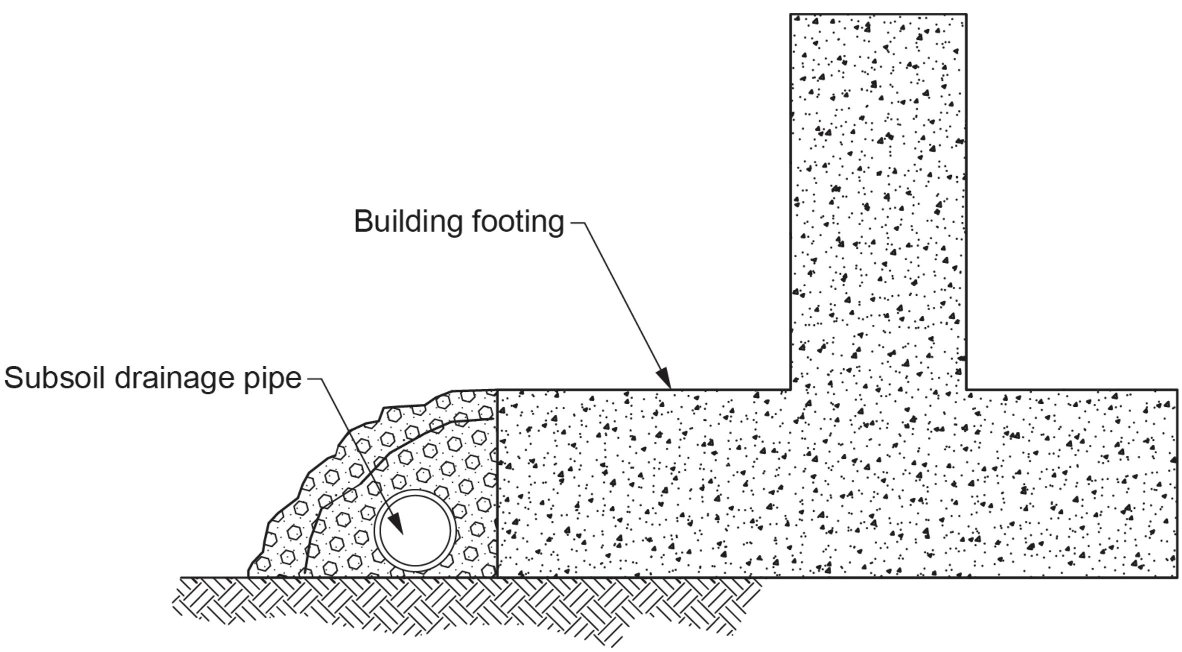

Figure 5 *Subsoil drainage pipe. (Skilled Trades BC, 2021) Used with permission.*

Self Test D-3.1: Storm Drainage Terminology

Complete Self Test D-3.1 and check your answers.

If you are using a printed copy, please find Self-Test D-3.1 and Answer Key at the end of this section. If you prefer, you can scan the QR code with your digital device to go directly to the interactive Self-Test.

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://d-drainagesystems-bcplumbingapprl2.pressbooks.tru.ca/?p=70#h5p-20 (https://d-drainagesystems-bcplumbingapprl2.pressbooks.tru.ca/?p=70#h5p-20)

References

Skilled Trades BC. (2021). *Book 2: Install fixtures and appliances, install sanitary and storm drainage systems.* Plumber apprenticeship program level 2 book 2 (Harmonized). Crown Publications: King's Printer for British Columbia.

Trades Training BC. (2021). D-3: Install storm drainage systems. In: *Plumber Apprenticeship Program: Level 2*. Industry Training Authority, BC.

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D-3.2 Functions of Pipes in Storm Drainage Systems

A storm drainage system is composed of storm water collection devices and the associated piping connected to the collection devices that transport the stormwater to an approved disposal location. This chapter describes the array of stormwater collection devices utilized and their function in the system.

Parts and Function

Roof drain: a drain installed through the roof deck or slab. It is generally a circular body made of cast iron with a dome-type strainer that receives stormwater on all sides of the drain. Roof drains are also available in spun copper (Figure 1) or aluminum styles that may or may not be furnished with strainers. Whenever you install a flat roof drain, ensure that strainers or domes are in place to prevent debris and other potential obstruction elements from getting into the drainage system.

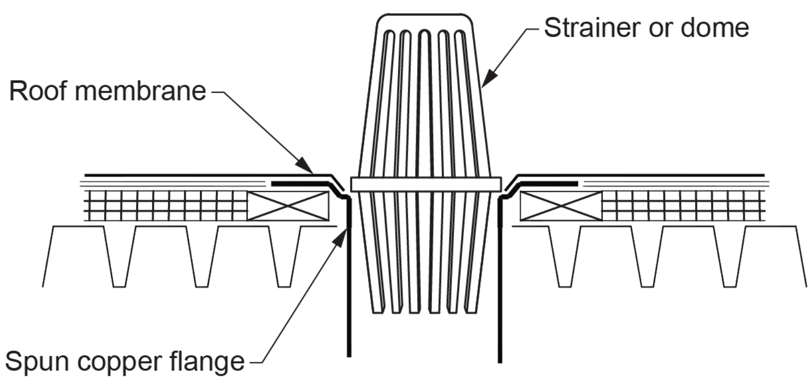

Figure 1 *Spun copper roof drain with stainer. (Skilled Trades BC, 2021) Used with permission.*

Flow-control roof drain: used to drain the roof at a controlled rate. Excess water is allowed to accumulate on the roof under controlled conditions. The water then drains off at a lower flow rate after a rain event. The roof must be structurally designed to temporarily store the maximum amount of water without overloading during periods of heavy rainfall.

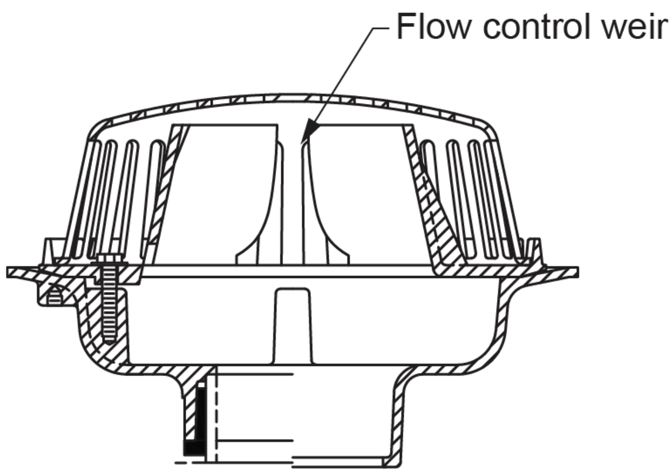

Figure 2 Flow-control roof drain. (Skilled Trades BC, 2021) Used with permission.

Siphonic roof drain: a drain designed to operate at full pipe capacity, which creates a siphonic condition. The siphonic condition allows water to drain faster than using conventional gravity roof drains. Because of the flow rates generated, a minimal number of roof drains are required, and they can be connected into a single rain leader.

Rainwater leaders (RWL): may be attached to the outside wall of a building or located within a building. They may be a sheet metal leader, a non-circular tubing material, or a pipe (Figure 3).

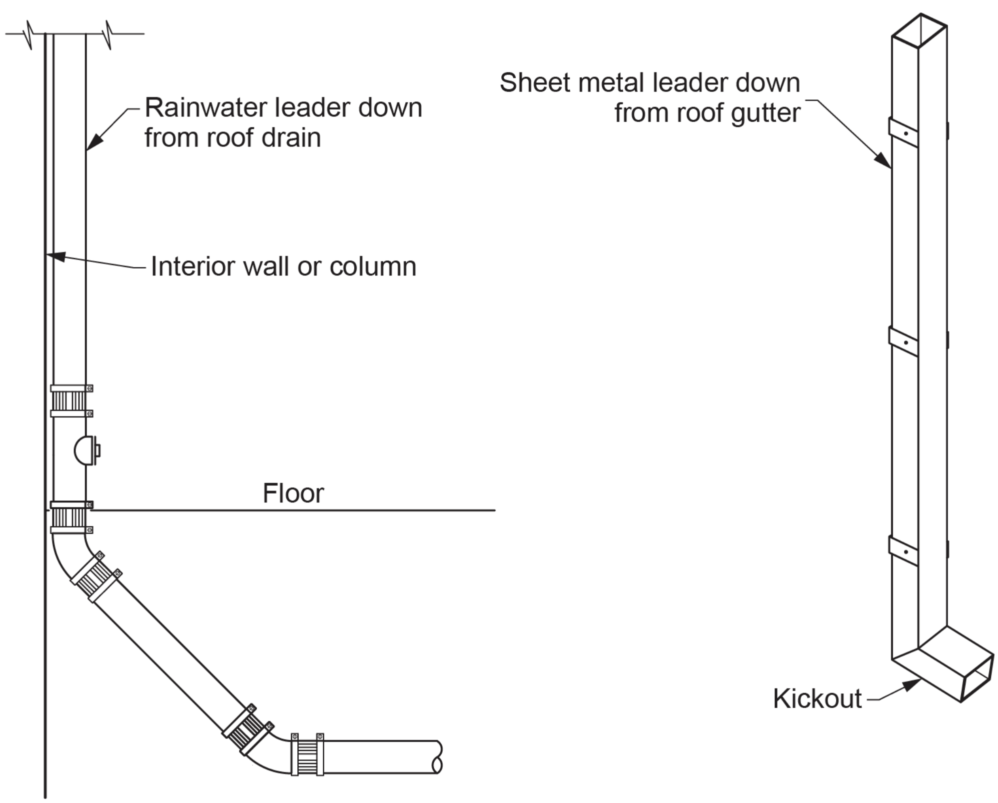

Figure 3 Interior and exterior rainwater leaders. (Skilled Trades BC, 2021) Used with permission.

Deck drain: a drain similar in all respects to a roof drain except that it generally has a flat strainer and is located in an area such as a walkway (Figure 4).

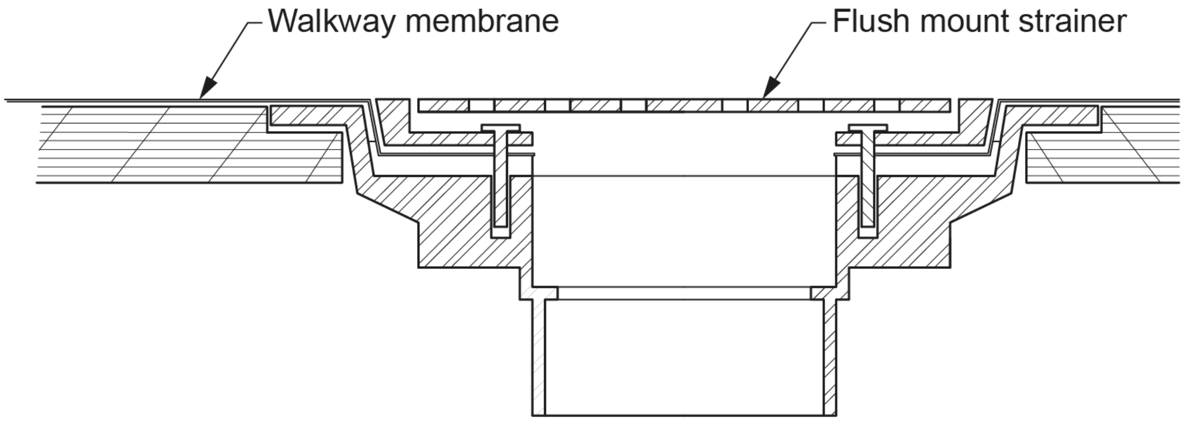

Figure 4 *Walkway deck drain. (Skilled Trades BC, 2021) Used with permission.*

Roof gutter: a collection device attached along the entire lower side of a pitched roof. Typically constructed of aluminum or steel with a corrosion-resistant coating and terminating at an external leader.

Roof scupper: a box-like collection device located on the exterior of a building and that receives stormwater on one side (Figure 5). Emergency scuppers are designed as overflow protection on flat roofs and are typically installed in conjunction with flow-control roof drains and parapet walls.

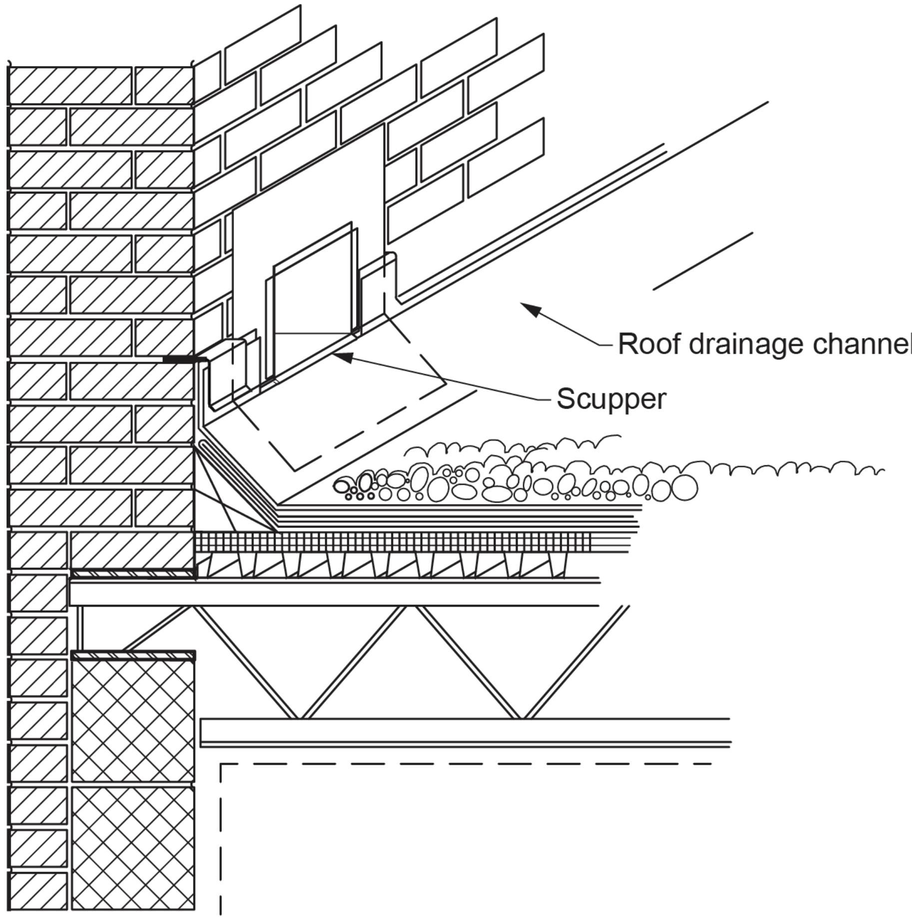

Figure 5 *Roof scupper. (Skilled Trades BC, 2021) Used with permission.*

Catch basin: a part of a storm drainage system used to drain paved areas, such as parking lots. Catch basins lead to storm sewers, which release the untreated water through outfalls directly into nearby streams or rivers. It is designed to trap debris to prevent it from entering the drainage pipes (Figure 6).

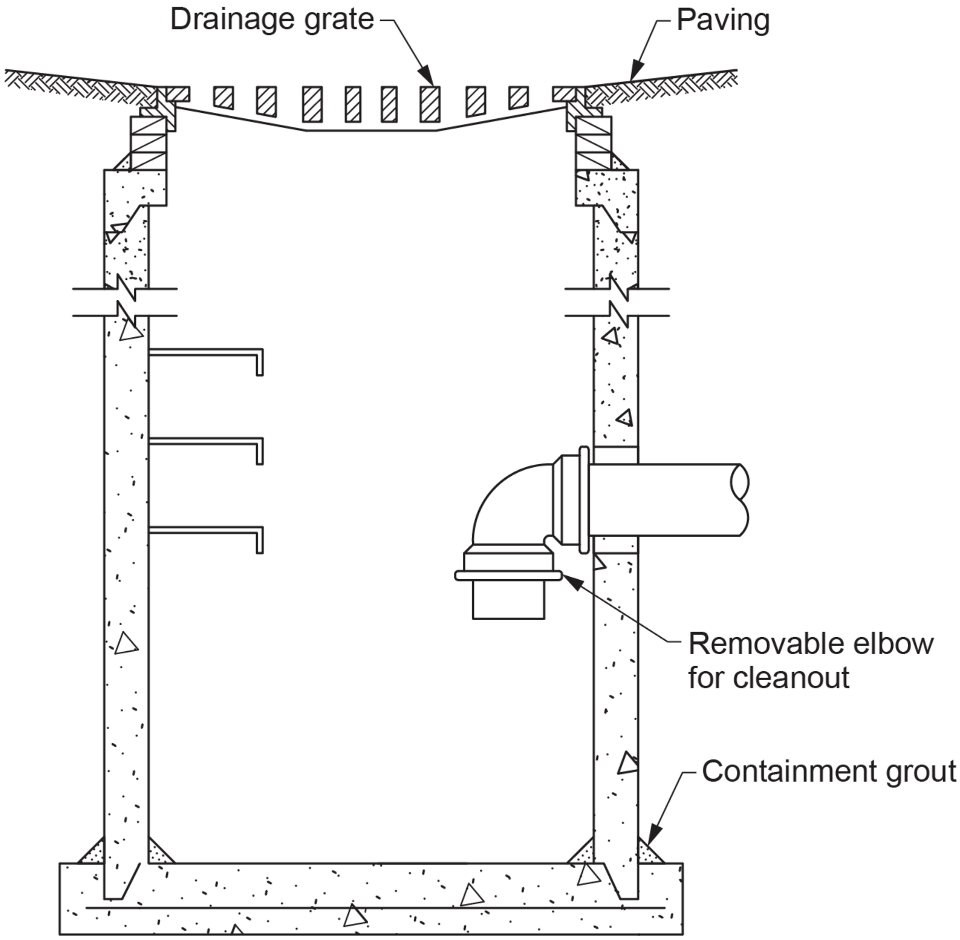

Figure 6 *Catch basin serving paved area. (Skilled Trades BC, 2021) Used with permission.*

Storm drainage piping systems: may be designed for gravity or pumped flow to a point of discharge. The AHJ regulates the discharge rate for stormwater systems according to a municipal stormwater management strategy.

Combined drainage piping systems: designed to collect both storm drainage (rainwater and snowmelt) and wastewater (sewage from homes and businesses) in the same pipe. These systems have serious drawbacks because during periods of heavy rainfall or snowmelt, the additional volume in a combined sewer system can exceed the capacity of the sewer system.

Although most jurisdictions have replaced or are replacing these systems with dedicated sewer systems for storm and sanitary drainage, there are existing systems that have not been converted. If this situation exists, some jurisdictions employ combined sewer overflows (CSOs). CSOs are designed to overflow and discharge the excess flow directly to a predetermined disposal area, such as a river, without reaching the sewage treatment plant.

Self-Test D-3.2: Functions of Pipes in Storm Drainage Systems

Complete Self-Test D-3.2 and check your answers.

If you are using a printed copy, please find Self-Test D-3.2 and Answer Key at the end of this section. If you prefer, you can scan the QR code with your digital device to go directly to the interactive Self-Test.

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References

Skilled Trades BC. (2021). *Book 2: Install fixtures and appliances, install sanitary and storm drainage systems*. Plumber apprenticeship program level 2 book 2 (Harmonized). Crown Publications: King's Printer for British Columbia.

Trades Training BC. (2021). D-3: Install storm drainage systems. In: *Plumber Apprenticeship Program: Level 2*. Industry Training Authority, BC.

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D-3.3 Storm Drainage Code Requirements

The National Plumbing Code (NPC) has established a minimum acceptable standard for the design and installation of storm and combined drainage systems. Because sanitary drainage systems were studied in Section E-1 of this series, this chapter will only focus on the sections of the NPC that deal with storm and combined drainage systems.

Piping Types

Piping materials used to construct an interior storm drainage system must be acceptable to the AHJ and the Code. Exposed leaders or downspouts should be capable of withstanding all anticipated abuses, corrosion, weather, and expected expansion and contraction. The piping may be the same material approved for sanitary drainage whether it is installed in any of the following ways:

- Above ground inside the building
- Underground under the building
- As a building sewer

The following are exceptions to the piping material approved for sanitary drainage.

Corrugated Steel Galvanized Pipe

Corrugated steel galvanized pipe is typically used in a variety of applications, such as culverts, stormwater detention systems, and storm sewers. Couplings for corrugated steel pipe shall be constructed so that, when installed, they:

- Maintain the pipe alignment
- Resist the separation of adjoining lengths of pipe
- Prevent root penetration
- Prevent the infiltration of surrounding material

Application

Table 1: Corrugated Steel Galvanized Pipe Application

Drainage System			Venting System	
Above Ground Inside Building	**Underground Under Building**	**Building Sewer**	**Above Ground**	**Underground**
N	N	P (only as a storm sewer)	N	N

Sheet Metal Leaders

A **sheet metal leader** shall not be used except above ground outside a building.

Piping Identification

The NPC requires that every length of pipe and every fitting have cast, stamped, or indelibly marked on it the maker's name or mark as well as the weight, class, or quality of the product. It must also be marked in accordance with the relevant standard. These **pipe markings** must be visible after installation.

Size

Rainwater leaders, storm and combined building drains, and storm and combined building sewers are all part of the storm drainage system. To size the above-mentioned piping sections, you must understand that the load to consider is measured in litres (L). For the load of litres to have any relationship to flow rate, there must be a time frame associated with it. The time frame used is a **15-minute rain event**. Even though the load on a pipe is expressed in litres, it really means it is litres per 15 minutes (L/15 min).

This 15-minute time frame is associated with climatic data listed in the National Building Code. This document lists different geographical locations and their **local rainfall intensity**. The rainfall intensity is the depth of water, in millimetres, received during a rain event over a 15 minute period, expressed as mm/15 min.

Determining the Drainage Load for a Flat Surface

To calculate the load in litres per 15 minutes from a roof or paved surface, we must know the area being drained. The area will be expressed in square metres (m^2). The question is, how do the area of a roof and the rainfall intensity relate to a load in litres per 15 minutes?

Figure 1 shows a roof surface with a roof drain in the centre. The area of the surface being served by the roof drain is 1 m^2.

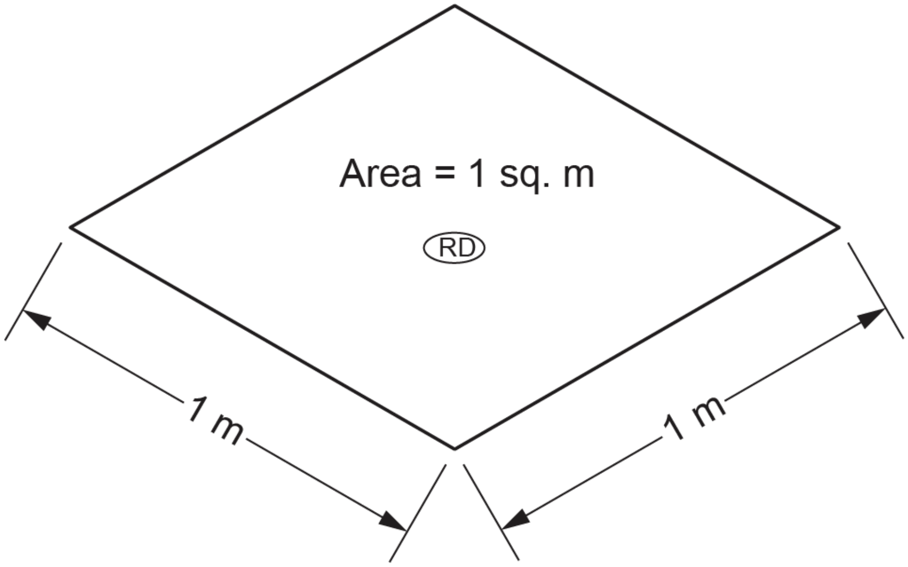

***Figure 1** 1 m^2 roof surface. (Skilled Trades BC, 2021) Used with permission.*

If the surface had a water depth of one mm, the resulting volume would be one litre. Why is that? Well, we must know that:

- The area measurement, one square metre (m^2), contains one million mm^2:

$$1000 \text{ mm} \times 1000 \text{ mm} = 1000000 \text{ mm}^2$$

- The volumetric measurement, one litre, contains one million mm^3 of volume:

$$1000 \text{ mm} \times 1000 \text{ mm} \times 1 \text{ mm} = 1000000 \text{ mm}^3$$

If the depth were 2 mm, then the volume of water on the surface would be 2 L, and so on. If this roof were located in Burnaby, BC, which has a rainfall intensity of 10 mm/15 min, then it could be deduced that the 1 m^2 surface area and the associated roof drain would receive 10 L of flow in 15 minutes.

To find the load for any drained surface expressed in litres per 15 minutes, simply multiply the area in m^2 by the rainfall intensity in millimetres per 15 minutes.

Example

Figure 2 shows a $12 \text{ m} \times 12 \text{ m}$ roof

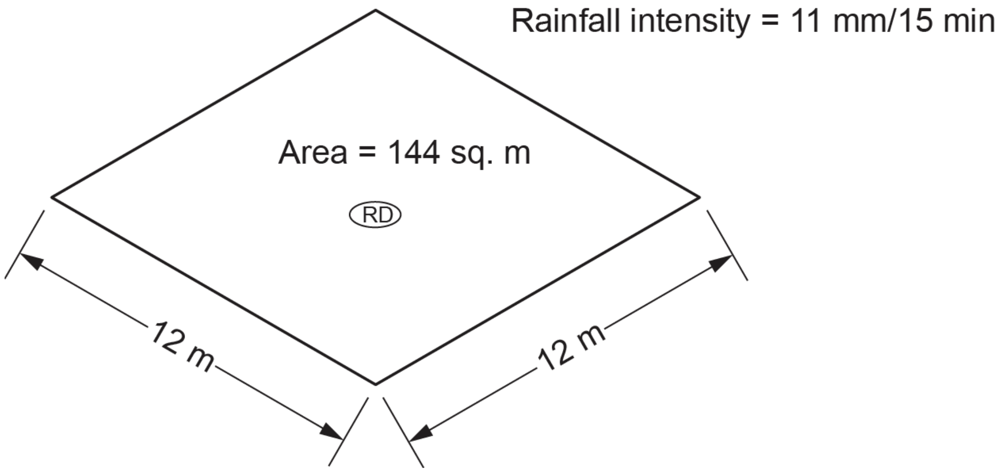

Figure 2 *Roof surface 12 m x 12 m. (Skilled Trades BC, 2021) Used with permission.*

Solution

1. Calculate the area of the roof surface:

$$12\ \text{m} \times 12\ \text{m} = 144\ \text{m}^2$$

2. Find the rainfall intensity given on the drawing:

$$11\ \text{mm}/15\ \text{min}$$

3. Determine the load on the roof drain:

$$144\ \text{m}^2 \times 11\ \text{mm}/15\ \text{min} = 1584\ \text{L}$$

Determining the Drainage Load for a Flat Surface With an Adjoining Wall

When determining the hydraulic load on the storm system from a roof with an adjoining wall, the calculation for the flat surface is the same as above (roof area x rainfall intensity). The NPC requires that the area of the wall be considered as well but not the whole wall; only one-half of the wall area must be considered when determining the effective area served by the roof drain.

Example

In Figure 3, a vertical adjoining wall has been added to our previous example. What is the load served by the roof drain?

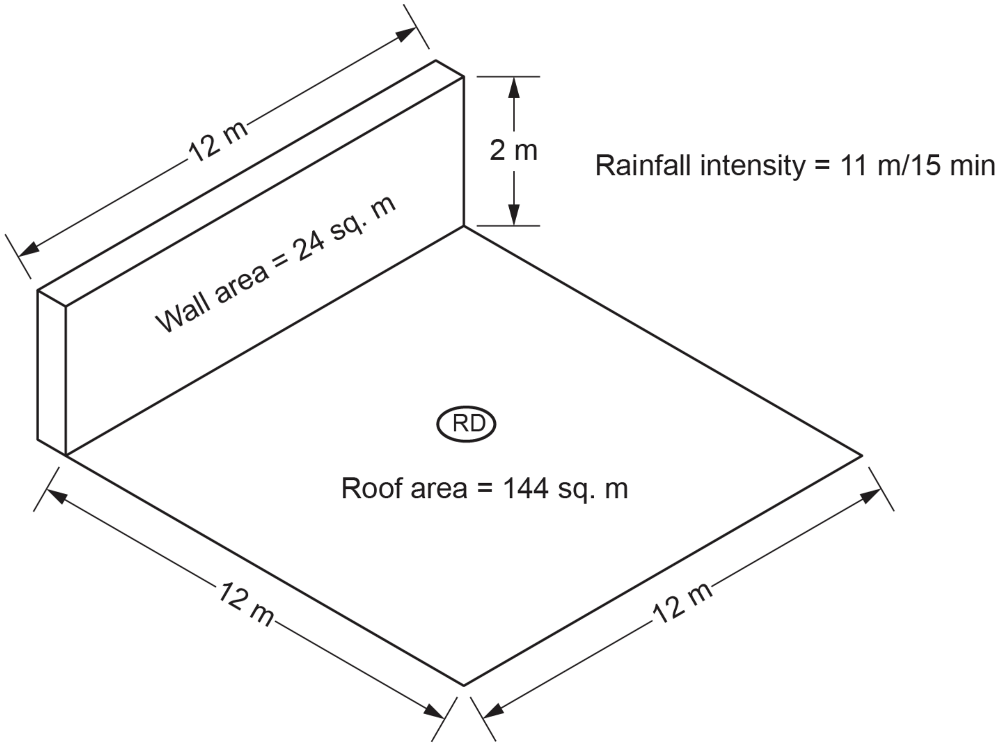

Figure 3 *Flat roof with vertical adjoining wall. (Skilled Trades BC, 2021) Used with permission.*

Solution

1. Calculate the area of the roof surface:

$$12\ \mathrm{m} \times 12\ \mathrm{m} = 144\ \mathrm{m}^2$$

2. Calculate the area of the wall surface and divide by 2 (one-half):

$$12\ \mathrm{m} \times 2\ \mathrm{m} = 24\ \mathrm{m}^2 \div 2 = 12\ \mathrm{m}^2$$

3. Calculate the total effective area served by the roof drain:

$$144\ \mathrm{m}^2\ (\mathrm{roof}) + 12\ \mathrm{m}^2\ (\mathrm{wall}) = 156\ \mathrm{m}^2$$

4. Find the rainfall intensity given on the drawing:

$$11\ \mathrm{mm}/15\ \mathrm{min}$$

5. Determine the load on the roof drain:

$$156\ \mathrm{m}^2 \times 11\ \mathrm{mm}/15\ \mathrm{min} = 1716\ \mathrm{L}$$

When determining the hydraulic load to the storm system from a roof with two or more adjoining walls, the NPC requires that only one-half of the largest adjoining wall area be considered.

Example

In Figure 4, a roof drain serves a flat roof surface and two vertical adjoining walls. Only half the area of the largest wall will be considered in our calculations, as the other wall will be ignored. The location of the installation has a rainfall intensity of 9 mm/15 min. What is the load served by the roof drain?

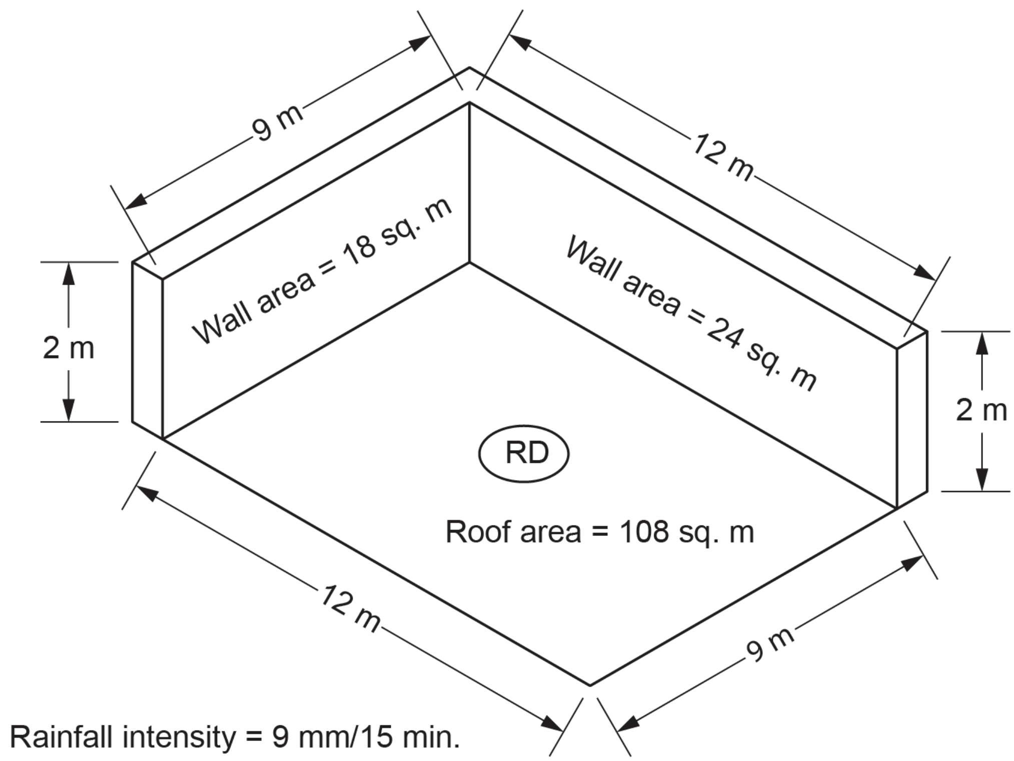

Figure 4 *Flat roof with two vertical adjoining walls. (Skilled Trades BC, 2021) Used with permission.*

Solution

1. Calculate the area of the roof surface:

$$9 \text{ m} \times 12 \text{ m} = 108 \text{ m}^2$$

2. Calculate the area of the largest wall surface and divide by 2 (one-half):

$$12 \text{ m} \times 2 \text{ m} = 24 \text{ m}^2 \div 2 = 12 \text{ m}^2$$

3. Calculate the total effective area served by the roof drain:

$$108 \text{ m}^2 \text{ (roof)} + 12 \text{ m}^2 \text{ (wall)} = 120 \text{ m}^2$$

4. Find the rainfall intensity given on the drawing:

$$9 \text{ mm}/15 \text{ min}$$

5. Determine the load on the roof drain:

$$120 \text{ m}^2 \times 9 \text{ mm}/15 \text{ min} = 1080 \text{ L}$$

Determining the Load From an Appliance That Produces Semi-continuous or Continuous Flow

Fixtures and appliances that discharge semi-continuous or continuous flow are allowed to drain to either sanitary or storm drainage systems. The one stipulation is that only fixtures or appliances that discharge clearwater waste may drain to a storm drainage system. Recall from Section D-1 that when a fixture with semi-continuous or continuous flow drains to a sanitary drainage system, the flow rate from that fixture is expressed in litres per second is multiplied by 31.7 to find the hydraulic load, expressed in **fixture units (FUs)**, imposed on the sanitary system by that fixture. Also, the size of the trap serving that flow was sized from Table 2.4.10.12. based on the flow rate, in litres per second, from that fixture. The reason we had to convert between a flow rate in litres per second to fixture units is that all sanitary drainage piping uses fixture units as the measurement for hydraulic load.

In storm and combined drainage systems, the unit of measure for hydraulic load is litres per 15 minutes. Because of this, when connecting a semi-continuous or continuous flow appliance with a flow rate expressed in litres per second to a storm or combined drainage system, another conversion must be used. To accomplish this, as stated in Clause 2.4.10.3.(2), simply multiply the flow rate (L/s) by 900 (number of seconds in 15 minutes) to get a hydraulic load in the proper format (L/15 min) for sizing the storm or combined system.

Example

What would be the hydraulic load imposed on a storm or combined drainage system when the flow rate from the fixture or appliance is 0.35 L/s?

Solution

Convert the flow rate in L/s to L/15 min:

$$0.35 \text{ L}/\text{ s} \times 900 \text{ s}/15 \text{ min} = \text{ L}/15 \text{ min } 0.35 \times 900 = 315 \text{ L}/15 \text{ min}$$

Figure 5 compares the hydraulic loads when connecting an identical appliance to both a SOWS and an RWL. Pay special attention to the size of the RWL downstream of the appliance connection and why its size must be larger than required by the code tables.

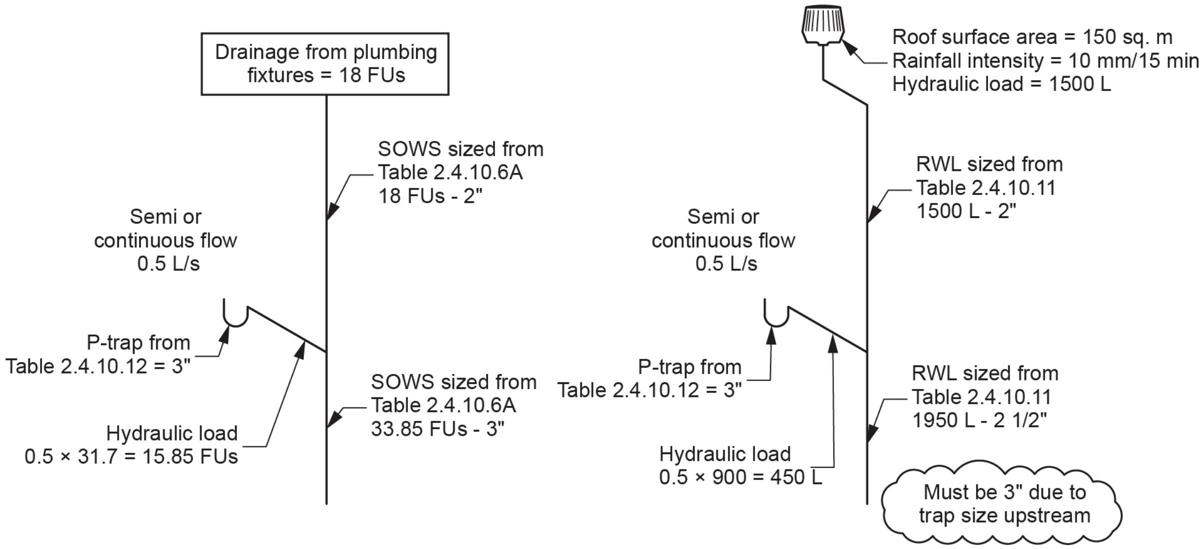

Figure 5 *A comparison of a semi-continuous or continuous fixture or appliance draining to storm and sanitary. (Skilled Trades BC, 2021) Used with permission.*

NPC Sizing Tables

Sizing pipe for a storm or combined drainage system is a relatively straightforward process once you are familiar with the tables provided in the NPC book. These tables provide the minimum size of all drainage pipes based on the load, in litres, it can carry for any particular size. Remember that the load on any pipe section is the load draining to it from upstream.

Because there are different tables for sizing leaders, gutters, and building drains/sewers, you must be able to properly identify the proper table for the pipe section you are sizing.

The following tables are the ones you will need to refer to.

Table 2.4.10.9. — Maximum Permitted Hydraulic Load Drained to a Storm Building Drain or Sewer or a Combined Building Sewer

The storm or combined building drain conducts flow from the furthest point upstream and terminates 1 m outside the foundation. At this point, the storm or combined building sewer is established and conducts the flow to an approved disposal system. To determine the size of any portion of the storm or combined building drain or the storm or combined building sewer, you must know the drainage load in litres (L) and the pipe grade. Notice that for any pipe size, the load-carrying capacity of the pipe increases as the grade is increased.

Table 2: (Table 2.4.10.9.) Maximum Permitted Hydraulic Load Drained to a Storm Building Drain or Sewer or a Combined Building Sewer

Size of Drain or Sewer (in.)	Maximum Hydraulic Load (L)						
	Slope						
	1 in 400	1 in 200	1 in 133	1 in 100	1 in 68	in 50	1 in 25
3	N/A	N/A	N/A	N/A	N/A	2,770	3,910
4	N/A	N/A	N/A	4,220	5,160	5,970	8,430
5	N/A	N/A	6,760	7,650	9,350	10,800	15,300
6	N/A	N/A	10,700	12,400	15,200	17,600	24,900
8	N/A	18,900	23,200	26,700	32,800	37,800	53,600
10	N/A	34,300	41,900	48,500	59,400	68,600	97,000
12	37,400	55,900	68,300	78,700	96,500	112,000	158,000
15	71,400	101,000	143,000	143,000	175,000	202,000	287,000

Table 2.4.10.10. — Maximum Permitted Hydraulic Load Drained to a Roof Gutter

To use this table, you need the load on the sloped roof as determined by its effective area and local rainfall intensity. Once the load has been determined, the slope of the gutter, in the direction of flow, becomes a determining factor. Once the slope ratio has been determined, the size of the gutter can be found in the column on the right side of the table. **Gutter sizing** and installation are not normally performed by plumbers. Gutter installation companies take care of gutters and external leaders.

Table 3: (Table 2.4.10.10.) Maximum Permitted Hydraulic Load Drained to a Roof Gutter

Size of Gutter (in.)	Area of Gutter (cm^2)	Maximum Hydraulic Load (L)			
		Slope			
		1 in 200	1 in 100	1 in 50	1 in 25
3	22.8	406	559	812	1,140
4	40.5	838	1,190	1,700	2,410
5	63.3	1,470	2,080	2,950	4,170
6	91.2	2,260	3,200	4,520	6,530
7	124.1	3,250	4,600	6,500	9,190
8	162.1	4,700	6,600	9,400	13,200
10	253.4	8,480	12,000	17,000	23,600

Table 2.4.10.11. — Maximum Permitted Hydraulic Load Drained to a Leader

To use this table, you need to calculate the load on the leader, as determined by the effective area drained and local rainfall intensity. Once the load has been determined, you have a leader material choice between circular (pipe) and non-circular (downspout). Now, follow the appropriate column down to the calculated load's range to determine the leader's size.

Table 4: (Table 2.4.10.11.) Maximum Permitted Hydraulic Load Drained to a Leader

Circular Leader		Non-Circular Leader	
Size of Leader (in.)	Maximum Hydraulic Load (L)	Area of Leader (cm^2)	Maximum Hydraulic Load (L)
2.5	3,070	31.6	2,770
3	5,000	45.6	4,500
4	10,800	81.1	9,700
5	19,500	126.6	17,600
6	31,800	182.4	28,700
8	68,300	324.3	61,500

Table 2.4.10.12. — Maximum Permitted Hydraulic Load From Fixtures With a Semi-continuous Flow

Sometimes, we need to size a trap serving a clearwater-waste–producing appliance that drains to a leader. When the flow is continuous or semi-continuous and expressed in litres per second (L/s), we can use that flow rate to find the minimum trap size in this table.

Table 5: (Table 2.4.10.12.) Maximum Permitted Hydraulic Load From Fixtures With a Semi-continuous Flow

Trap Size (in.)	Flow Rate (L/s)	Hydraulic Load (FUs)
1.5	0.00–0.090	3
2	0.091–0.190	6
3	0.191–0.850	27
4	0.851–5.700	180

Sizing Procedures

When sizing storm and combined drainage systems, there are three different hydraulic load that could contribute to the process:

- Sanitary drainage from plumbing fixtures, expressed in FUs
- Storm drainage from roofs and paved surfaces, expressed in **litres per 15 minutes**
- Combined storm and sanitary drainage, expressed in litres per 15 minutes

The sizing process is best described by examining the hydraulic load contributors individually.

Sizing Sanitary Drainage

This process was described in detail in Section E-1, so we will not dwell on this subject. It is important to note that the hydraulic load generated by the sanitary system will become important later when we size the combined drainage system.

Sizing Storm Drainage

This process is relatively straightforward once the hydraulic load has been determined. The steps to follow are:

1. Determine the effective area in m^2 of roofs and paved surfaces.
2. Determine the local rainfall intensity (millimetres per 15 minutes of rainfall) found in the National Building Code.
3. Multiply the effective area by the rainfall intensity to obtain the hydraulic load in litres per 15 minutes.

Additional loads that may be considered when sizing a storm drainage system include:

- If a clearwater waste appliance or fixture discharges a continuous or semi-continuous flow to the storm system, multiply its load in litres per second by 900 to obtain the hydraulic load in litres per 15 minutes.
- If using flow-control roof drains, compute the discharge rate based on rain intensity, retention duration, accumulation height, and roof area from the roof drain manufacturer's data.

Add all contributing hydraulic loads listed above to obtain the total hydraulic load on the storm drainage pipe in litres per 15 minutes. Then, consult the appropriate table from among Tables 2.4.10.9., 2.4.10.10., and 2.4.10.11. to select the drain, leader, or gutter size.

Storm Drainage Sizing Example

You can refer to Figure 6 to see the hydraulic load calculations in Table 6 illustrated on a map of a storm drainage system. Because there is no such thing as storm branches, all horizontal storm drainage pipes will be sized as storm building drains using the given grade ratio.

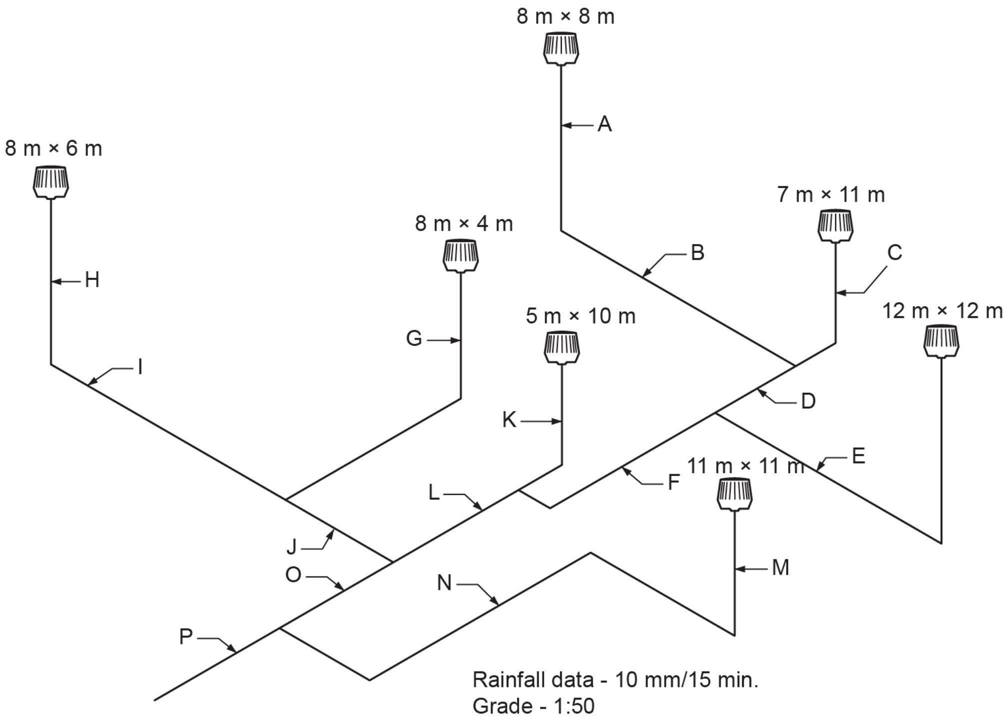

Figure 6 *Storm drainage system example. (Skilled Trades BC, 2021) Used with permission.*

Table 6: Hydraulic Load Calculations for Storm Drainage

Label	Name	Leader (m^2)	Load (L)	Size
A	RWL	64	640	2 in.
B	Storm building drain	–	640	3 in.
C	RWL	77	770	2 in.
D	Storm building drain	–	1,410	3 in.
E	Storm building drain	–	1,440	3 ft
F	Storm building drain	–	2,850	4 in.
G	RWL	32	320	2 in.
H	RWL	48	480	2 in.
I	Storm building drain	–	480	3 in.
J	–	–	800	3 in.
K	RWL	50	500	2 in.
L	Storm building drain	–	3,350	4 in.
M	RWL	121	1,210	2 in.
N	Storm building drain	–	1,210	3 in.
O	Storm building drain	–	4,150	4 in.
P	Storm building drain	–	5,360	4 in.

Sizing Combined Drainage

This process is more complex than the procedures we used in the above explanations. When sanitary drainage is connected to a combined drain or sewer, only the hydraulic load from the plumbing fixtures must be converted from fixture units to litres per 15 minutes or, in the case of continuous flow, from litres per second to litres per 15 minutes so that these loads can be added to the hydraulic loads from roofs and paved surfaces. Unfortunately, the relationship between fixture units and litres per second and, consequently, the relationship between fixture units and litres, is not easily calculated. To make the sizing process easier to navigate, the NPC has adopted an approximate conversion factor.

The conversion factor is detailed in Sentence 2.4.10.5.(1) of the NPC, which says to apply a hydraulic load of 9.1 L/15 min for each fixture unit drained to the combined drainage system. This holds true only when the total sanitary drainage load draining to any particular pipe section is greater than 260 FUs. When the load is 260 FUs or less, use a round figure of 2,360 L.

As stated earlier, when semi-continuous or continuous flow appliances or fixtures drain to combined sewers or storm sewers, the factor for converting flow of the fixture from litres per second to litres per 15 minutes is 900 (given in Sentence 2.4.10.3.[2]). This conversion factor is not an approximation but an exact calculation.

It is important to note that the conversion factors given in Sentences 2.4.10.3.(1) and 2.4.10.5.(1) are designed to convert in one direction only and must not be used to convert from fixture units to litres per second in the one instance nor from litres to fixture units in the other instance.

The sizing process for combined drainage systems requires you to determine the load on the section of pipe you are sizing and to find the pipe size from Table 2.4.10.9. in the NPC. Determining the load on any section of a combined drainage system requires the following four distinct steps.

Step 1

Determine the total load in fixture units from all upstream plumbing fixtures except semi-continuous or continuous flow appliances or fixtures draining to the sanitary system upstream. The load imposed by these fixtures or appliances will be accounted for in Step 2. If the fixture unit load exceeds 260, multiply it by 9.1 to determine the equivalent hydraulic load in litres per 15 minutes. If the fixture unit load is 260 or fewer fixture units, the hydraulic load is determined to be 2,360 L/15 min.

Note: When sizing a combined building drain, do NOT assume a 2,360 L load for each sanitary drainage load as it enters the combined drainage system. The total fixture unit load on any section must be calculated separately.

Step 2

Determine the hydraulic load in litres per second from any semi-continuous or continuous flow source connected to the sanitary or storm drainage system and multiply by 900 to get a hydraulic load in litres per 15 minutes; this is the same procedure used when sizing storm drainage pipes.

Step 3

Determine the hydraulic load (L/15 min) from roofs and paved surfaces using the same procedure employed when sizing storm drainage pipes (effective area [m^2] × rainfall intensity [mm/15 min]).

Step 4

Add the hydraulic loads calculated in Steps 1 through 3 to obtain the total hydraulic load on the combined drainage pipe in litres per 15 minutes, and then consult Table 2.4.10.9. to select the pipe size.

Storm and Combined Drainage Sizing Example

Refer to Figure 7 to see the hydraulic load calculations in Table 7 illustrated on a map of a combined drainage system. Size all horizontal pipe sections as storm, sanitary, or combined building drains using the given grade ratio.

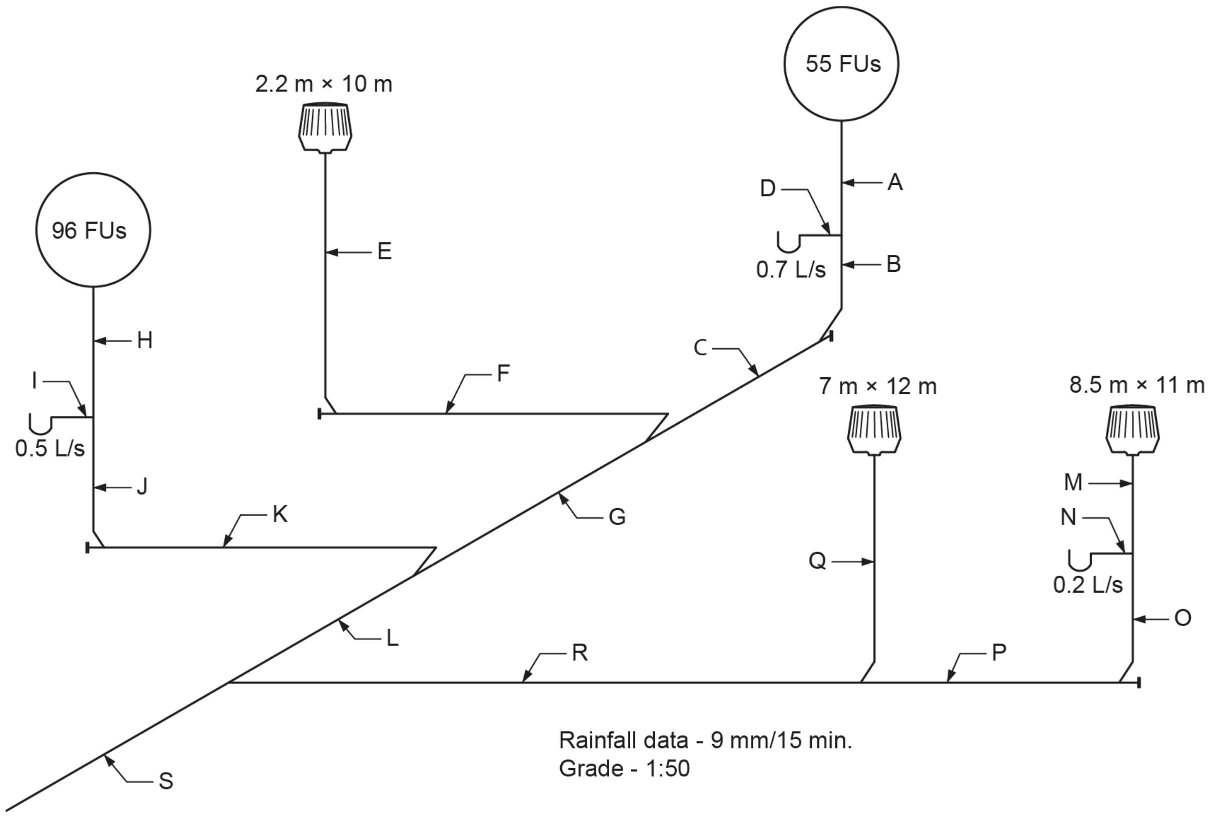

Figure 7 *Combined drainage system example. (Skilled Trades BC, 2021) Used with permission.*

Table 7: Hydraulic Load Calculations for Storm and Combined Drainage

Label	Name	Leader (m^2)	Load	Size (in.)
A	SOWS	–	55 FUs	3
B	SOWS	–	77.19 FUs	3
C	Sanitary building drain	–	77.19 FUs	4
D	Trap arm fixture drain	–	22.19 FUs	3
E	RWL	22	198 L	2
F	Storm building drain	–	198L	3
G	Combined building drain	–	3188 L Sanitary 55 FUs = 2360 L semi or cont. flow 0.7 L/s = 630 L Storm drainage = 198 L	4
H	SOWS	–	96 FUs	3
I	Trap arm fixture drain	–	15.85 FUs	3
J	SOWS	–	111.85 FUs	4
K	Sanitary building drain	–	111.85 FUs	4
L	Combined building drain	–	3638 L Sanitary 151 FUs = 2360 L semi or cont. flow 1.2 L/s = 1080 L Storm drainage = 198 L	4
M	RWL	93.5	841.5 L	2
N	Trap arm fixture drain	–	180 L	3
O	RWL	93.5	1021.5 L	3
P	Storm building drain	–	1,021.5 L	3
Q	RWL	84	756 L	2
R	Storm building drain	–	1,777.5 L	3
S	Combined building drain	–	5,415.5 L Sanitary 151 FUs = 2360 L Semi/Continous flow 1.4 L/s = 1260 L Storm drainage = 1795.5 L	4

Slopes

The slope ratio used with storm drainage systems must be steep enough to provide a flow velocity between 0.6 and 0.9 m/s to avoid excess water retention at the drain location. The NPC states that every drainage pipe with a size of 75 mm

(3 in.) or less shall have a downward slope in the direction of flow of at least one in 50 ($\frac{1}{3}$ in./ft.), with the exception of a storm and combined building drain or sewer larger than 75 mm. For example, a 100 mm (4 in.) storm building drain or storm building sewer is permitted to be sloped at 1:100 ($\frac{1}{8}$ in./ft.).

Fittings

The fittings used in storm drainage systems are the same DWV type used in sanitary drainage systems. However, expansion and contraction are a concern when a roof drain joins into a leader. The NPC requires that the roof drain be tightly connected to the leader and that provisions be made for expansion and contraction. You could accomplish this using an expansion joint or loop at the roof drain in the horizontal section of the leader to accommodate the leader's movement without affecting the roof drain.

Due to a possible surcharge condition during a high-flow event, vertical leaders should be connected to the building drain with single-wye fittings; the use of double-wye fittings should be avoided.

Orientation

Quite often, the roof drain and the leader location do not line up, and an offset is required. The NPC has certain requirements with regard to leader offsets, as stated in Clause 2.4.9.5.:

- There is no requirement to change the size of the leader with a nominally horizontal offset if the offset is located immediately under the roof and is not more than 6 m (19 ft 8 in.) long with a 1:50 minimum slope.
- If the horizontal offset is more than 6 m long, the leader shall be sized as a storm building drain using Table 2.4.10.9.

Appliance and Fixture Connections to a Storm Drainage System

In Clause 2.4.2.1.(1), the NPC states certain limitations on the type of appliances or fixtures that may drain into a storm drainage system. The items that may be connected are:

- A drinking fountain, provided that if it is subject to backflow, a **backwater valve** is installed in the drinking fountain waste pipe.
- Drainage pans from HVAC equipment, provided that if it is subject to backflow, a backwater valve is installed.
- A floor drain, provided that it is located where it can only receive clearwater waste or stormwater.

Fixture drains from the following appliances or fixtures may be directly connected to a common pipe:

- Fixtures used to display, store, prepare or process food and drinks
- Sterilizers

- Appliances that use water as heating or cooling mediums
- Water-operated devices
- Water-treatment devices
- Drains or overflows from a water or heating systems

Code states that the first two fixture types (the display case and the sterilizer) should drain into a sanitary drainage system because they are not considered clearwater waste. The following four types of fixtures could drain to either a sanitary or storm drainage system because they are considered to discharge clearwater waste.

This common pipe must be indirectly connected using an air break above the flood level rim of a fixture directly connected to a drainage system. When this provision is employed, the indirectly connected pipe must pass full-size through the roof if it receives discharge from three or more storeys.

Flow-Control Roof Drains

Controlled-flow systems collect rainwater on the roof and release the flow slowly to the drainage system. These systems can provide significant installation savings because they require smaller "flow-control" roof drains and smaller-diameter piping. These systems also reduce the impact on the sewage treatment plant from combined storm/sanitary sewer systems in locations where they are allowed.

In Clause 2.4.10.4.(2), the NPC states certain requirements when flow-control roof drains are employed and water is allowed to pond on the roof. Flow-control roof drains may be installed provided that:

- The maximum drain down time of the stored water does not exceed 24 hours.
- A structural engineer has deemed that the roof structure design is able to carry the weight of the stored water.
- The flow-control roof drains are located not more than 15 m (49 ft) from the edge of the roof and not more than 30 m (100 ft) from adjacent drains.
- There is at least one flow-control roof drain installed for every 900 m^2 (9,687 ft^2) of roof area.
- One or more overflow **scuppers** are installed along the perimetre of the building not more than 30 m (100 ft) apart. The overflow scuppers must provide protection so that up to 200% of the local 15-minute rainfall intensity can be drained, with the maximum depth of controlled water limited to 150 mm (6 in.).

Roof Drainage Emergency Overflow and Scuppers

Emergency overflow systems are referred to as secondary drainage systems and may be either scuppers, which allow the entrapped rainwater to overflow the roof, or a separately piped drainage system. The secondary piping system is installed separately from the primary system and discharged to an approved disposal point, preferably above grade, so building personnel can see that the primary drainage system is blocked.

In Clause 2.4.10.4.(2)(c), the NPC states certain regulations when installing these systems. When the height of the parapet wall is more than 150 mm (6 in.) or exceeds the height of the adjacent wall flashing, emergency roof overflows or scuppers shall be provided along with a minimum of two roof drains serving the roof. The requirements for the scupper locations and spacing are the same as the scupper requirements for flow-control roof drains, as mentioned earlier.

Prohibitions

The NPC has a number of prohibitions when installing storm drainage systems, including that it is prohibited to:

- Install a combined building drain unless it has been proven by past performance to be acceptable in some localities. If this is the case, then the installation of a combined building drain may be accepted.
- Install a sheet metal leader inside a building.
- Directly connect an overflow from a rainwater tank to a storm drainage system.
- Have a vertical soil or waste pipe conducting both sewage and stormwater.
- Have unused open ends in a drainage system, and when a dead end is provided, it must be graded so that it cannot retain water.

Traps

The NPC requires that where a storm drainage system connects to a combined building sewer or a public combined sewer, a trap, known as a building trap, shall be installed between any opening in the system and the drain or sewer. The one exception is that a trap is not required if the opening is the upper end of a leader that terminates at a roof used only for weather protection that is:

- Not less than 1 m (39 in.) above
- Not less than 3.5 m (11 ft $5\frac{4}{5}$ in.) in any other direction from any air inlet, openable window, or door
- Not less than 1.8 m (5 ft $10\frac{7}{8}$ in.) from a property line

A floor drain that drains to a storm drainage system shall be protected by a trap. The trap must be located between the floor drain and a leader, storm building drain, or storm building sewer. This single trap may serve all floor drains located in the same room and need not be protected by a vent pipe.

Where freezing conditions could cause storm drainage systems to freeze due to air circulation within the piping, a trap with a cleanout shall be installed in a heated location.

Cleanouts

The NPC has certain construction and location requirements for cleanouts serving DWV systems, as described in Section E-1. Those requirements apply to storm drainage systems as well.

As an example, every interior leader shall be provided with a cleanout fitting at the bottom of the leader, not more than 3 m (9 ft 10 in.) upstream of the bottom of the leader. This requirement is identical to the requirement for cleanouts at the base of a SOWS.

Venting

The NPC does not require venting in storm drainage systems, even if a trap is serving the system in some capacity.

Hangers and Supports

The hangers used must be compatible with the pipe they are supporting. You must use a hanger that will not be detrimental affected by corrosion on the piping. Due to the expansion and contraction effects experienced in storm drainage systems, the support system must always keep the pipe and fittings in proper alignment. A riser clamp should be provided at each floor line to support a leader. At the lower floors, all exterior leaders that may be damaged when installed in parking or truck-loading areas should be adequately supported and protected by sufficient guards.

Spacing

The NPC regulation states the maximum distance between supports and does not differentiate between storm and sanitary drainage piping. Depending upon the type of material you are using and whether the pipe is installed horizontally or vertically, the spacing between supports will vary.

Insulation

Low-temperature liquid flow in the storm interior drainage piping causes condensation to form on the outside of the piping, possibly causing stain damage to the ceilings or, where exposed, drip marks on the flooring. The NPC requires that an internal leader be insulated to protect the building interior from condensation. The insulation type and thermal properties may differ from job to job, so it is important to refer to the job specification requirements prior to installation.

Self-Test D-3.3: Storm Drainage Code Requirements

Complete Self-Test D-3.3 and check your answers.

If you are using a printed copy, please find Self-Test D-3.3 and Answer Key at the end of this section. If you prefer, you can scan the QR code with your digital device to go directly to the interactive Self-Test.

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Skilled Trades BC. (2021). *Book 2: Install fixtures and appliances, install sanitary and storm drainage systems.* Plumber apprenticeship program level 2 book 2 (Harmonized). Crown Publications: King's Printer for British Columbia.

Trades Training BC. (2021). D-3: Install storm drainage systems. In: *Plumber Apprenticeship Program: Level 2*. Industry Training Authority, BC.

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D-3.4 Planning the Storm System

Storm drain location must be coordinated with the architectural design of the building. The roof structure must be able to support the weight of **residual water** by design.

Location of Structure Penetrations

When planning the location of the roof drains, deck drains, scuppers, gutters, and rainwater leaders, consideration should be given to placing an overflow drain adjacent to each roof drain.

Scuppers are often used on flat roofs or on roofs with minimal slope for overflow protection. The amount of drainage provided by overflow drains or scuppers may be reduced on roofs that are flat or nearly flat. This is because under such circumstances, stormwater can flow to another drain before enough water can accumulate to cause damage to the structure. These overflow drains may be required by some local jurisdictions, so it is always good practice to check with the local plumbing officials. Even if the area served by a roof drain is relatively small, it is good practice to provide at least two drains in all individual roof areas.

Routing

The first step in planning a route for the storm drainage system is to find the locations of the drain outlets and their relation to interior walls and structural columns. This will help you determine the space available for installing the leaders. Locating the vertical leaders within the building as opposed to the building exterior has several advantages, such as convenience, safety, appearance, and freeze protection. However, leaders located on the exterior can be installed at a much lower cost and do not take up valuable floor space.

The piping layout must be coordinated with other trade disciplines that may be affected by the route, so to keep the number of leaders to a minimum, combine flows from more than one roof drain, clearwater wastes, or any combination thereof. If leaders are to be located at building columns, the column footing design must be coordinated with the structural engineer to take into consideration the leader location. Avoid running horizontal piping above the ceilings of computer rooms, kitchens, and food-preparation areas. A pipe rupture above one of these areas could cause major damage and contamination.

Pipe Supports

Expansion and contraction of the piping system installed without proper anchoring could cause roof drains to be pushed above the roof deck, destroying the integrity of the roof waterproofing by tearing the flashing and the waterproofing membrane. This problem can be more apparent in high-rise buildings and buildings where the exposed leader is subject to cold rainwater or melting snow and ice that enter piping at the ambient temperature of the building. Consider an expansion joint at the roof drain or a horizontal section of the branch line to accommodate the movement of the leader without affecting the roof drain.

Self Test D-3.4: Planning the Storm System

Complete Self Test D-3.4 and check your answers.

If you are using a printed copy, please find Self-Test D-3.4 and Answer Key at the end of this section. If you prefer, you can scan the QR code with your digital device to go directly to the interactive Self-Test.

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D-3.5 Installing Storm Drainage Systems

The storm drainage system installation has many of the same installation considerations as a sanitary drainage system; however, the roof penetrations will be connected to drains as opposed to vent terminations.

Safety

Construction sites are among the most dangerous and risky working environments. The installer must observe the **Occupational Health and Safety (OHS) Regulation** during all phases of a storm drainage system installation.

Pre-operational and safety checks are to be carried out on tools, equipment, and machinery according to manufacturer's specifications and site safety procedures. OHS hazards are identified, risks assessed, and risk controls implemented. The installation of storm drainage systems requires a worker to be aware when working at heights, in excavations, and in confined spaces, so always take appropriate safety precautions. The worker must also select, use, and maintain suitable personal protective equipment (PPE).

Tools and Equipment

Tools and equipment are selected according to the piping material used, the drainage system design requirements, and work site procedures.

Determining Slopes

The **minimum slopes** are dictated by the NPC depending on the size and function of the pipe. All drainage pipes must be installed with a minimum slope of 1:50. In some situations, the slope of the building drain may be reduced to 1:100 if it is at least 100 mm (4 in.) in size. This reduction in slope will allow for less fall over a given length, which may be needed to match the invert of a previously installed municipal drainage connection.

Installing Components

Installing and sealing a roof drain penetration where a waterproof roof membrane material is utilized requires knowledge of how the assembly is installed. The drain body is placed in the roof opening and held in place by an underdeck clamp. If a sump receiver is specified, it should be placed so that it is flush with the supporting edges of the drain body. The waterproof membrane will be installed over the sump receiver and drain body (Figure 1).

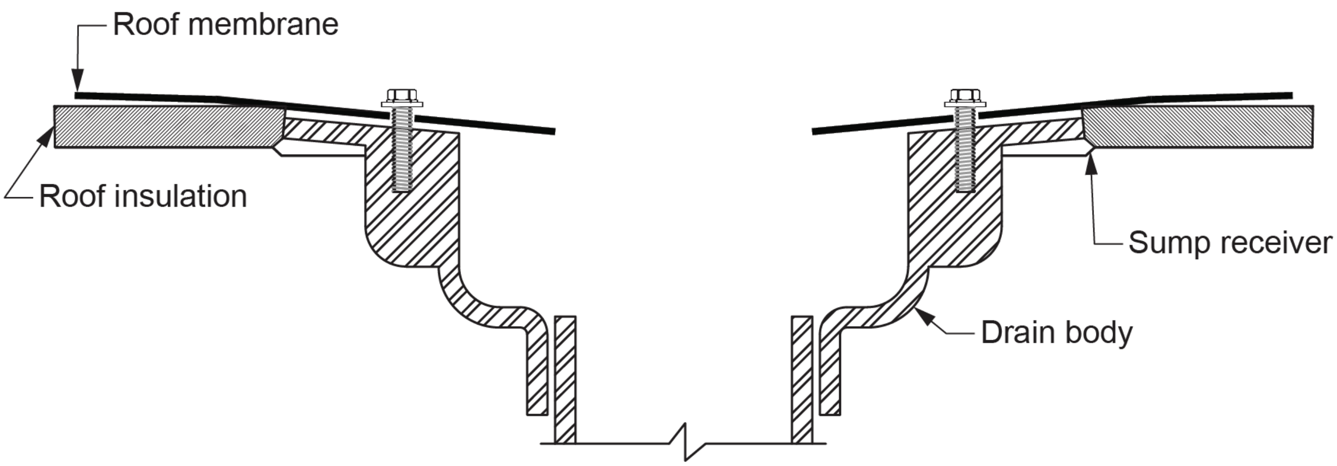

Figure 1 *Installation of a roof drain body. (Skilled Trades BC, 2021) Used with permission.*

The roof drain will be supplied with a **clamping collar** bolted through the drain body to clamp the roof membrane to the body, making a watertight seal. The dome is then placed into the clamping collar and twist-locked into retaining clips on the clamping collar (Figure 2).

Most commercial job sites will specify that a roofing contractor install the roof drain. The plumbing contractor's responsibility then is to supply and locate the drain. Always refer to the specific manufacturer's installation instructions when installing storm drainage components to ensure weather-tightness at the building penetrations.

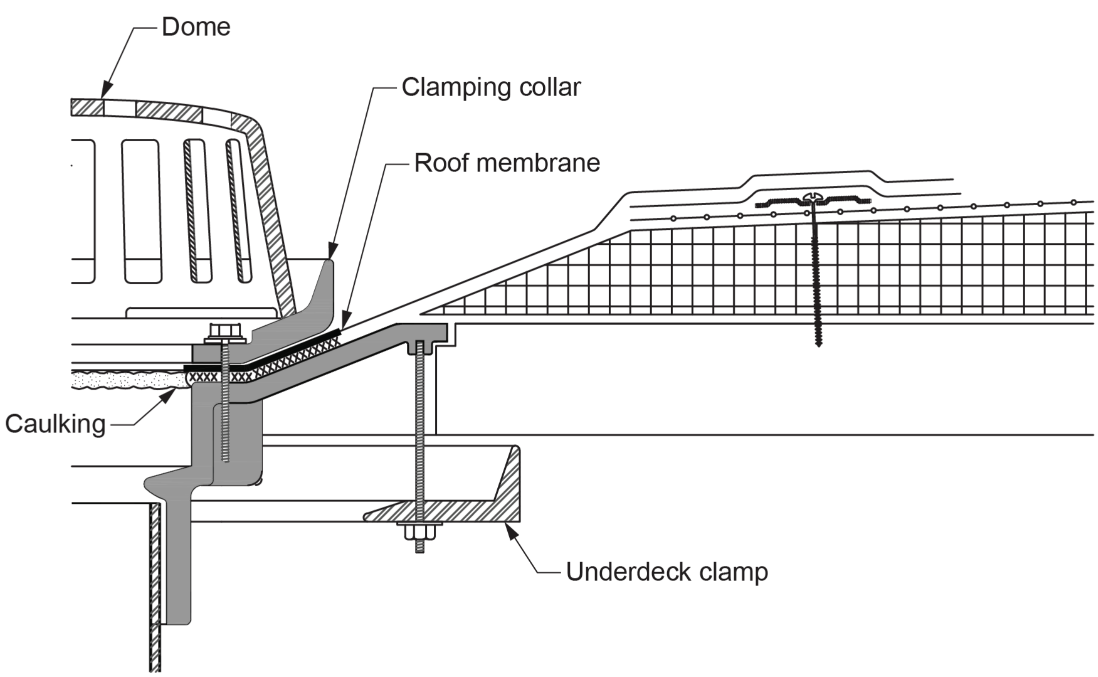

Figure 2 *Complete installation of a roof drain. (Skilled Trades BC, 2021) Used with permission.*

Self-Test D-3.5: Installing Storm Drainage Systems

Complete Self-Test D-3.5 and check your answers.

If you are using a printed copy, please find Self-Test D-3.5 and Answer Key at the end of this section. If you prefer, you can scan the QR code with your digital device to go directly to the interactive Self-Test.

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References

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Trades Training BC. (2021). D-3: Install storm drainage systems. In: *Plumber Apprenticeship Program: Level 2.* Industry Training Authority, BC.

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D-3.6 Sumps and Catch Basins

Storm water is often collecting in a catch basin or **sump** before being transfer to the public storm sewer of onsite storm water handing system.

Catch Basins

A **catch basin** is a type of **interceptor** that prevents debris, sand, grit, and other **contaminant**s from entering a drainage system. Catch basins can be found in curbs along the sides of roadways, in parking lots, along the edges of buildings, and in other low-lying areas. Smaller catch basins can be found as a part of landscaping and residential drainage systems, and sometimes, interior catch basins are used in parkades and other structures where outside water can make its way indoors.

A catch basin's purpose is to collect **surface water** (runoff from snow melt and rain) from low-lying areas on both public and private property. They are constructed to screen out, separate, and retain materials that would be detrimental to the operation of the storm systems that they drain into while allowing the water to drain away. Were it not for catch basins, water could be allowed to pool and present problems, such as flooding, street and property damage, and unsafe conditions for drivers and pedestrians.

Catch Basin Types

Catch basins are generally manufactured of concrete in round and rectangular configurations and in many different sizes to suit the application. Round catch basins (Figure 1) are designed to accept an eccentric concrete lid that may have one of various opening styles that suit the required casting. Grade or extension rings are used on top of the concrete lid to bring the drain grate assembly up vertically to match the grade of the surface being drained. Cylindrical catch basins are the more common variety used in the field.

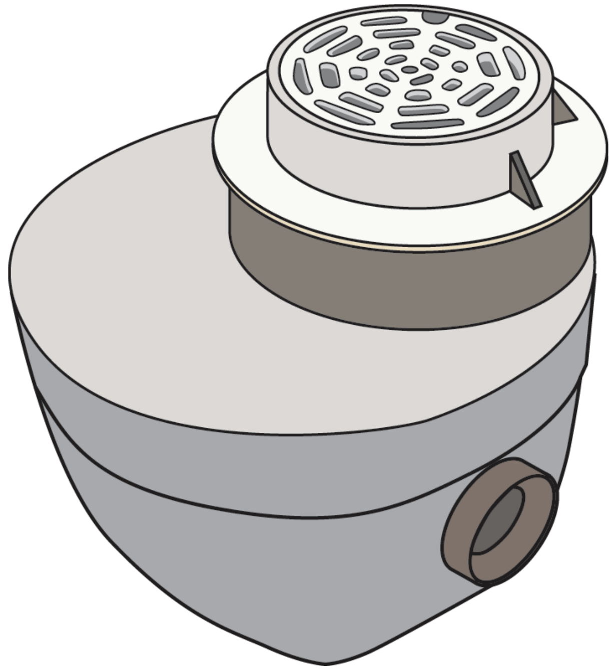

Figure 1 Cylindrical concrete catch basin. (Skilled Trades BC, 2021) Used with permission.

Rectangular catch basins are often designed to have the cast-iron frame and grate sit directly on top without needing a concrete lid (Figure 2).

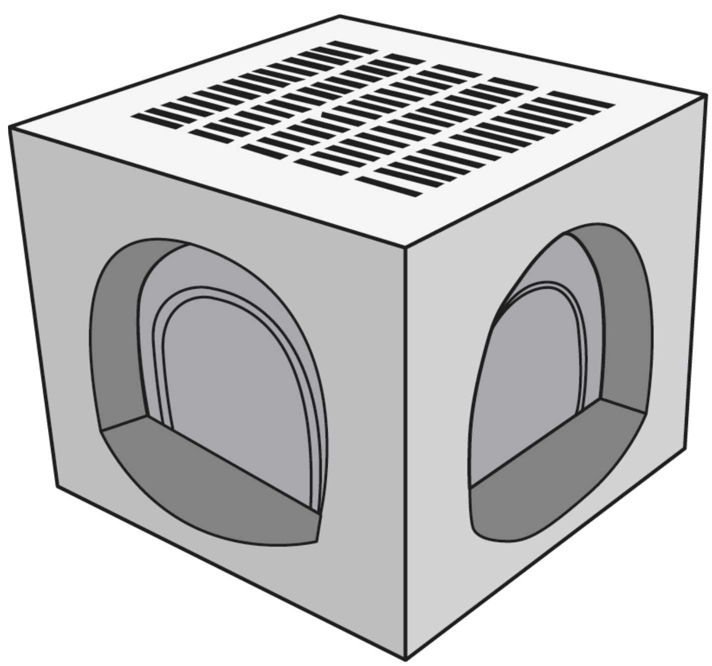

Figure 2 Rectangular catch basin. (Skilled Trades BC, 2021) Used with permission.

Reinforcing steel bars (rebar) and wire mesh are cast into high compressive strength concrete to ensure that the catch basin can withstand the loads imposed on them without fracturing. The catch basins may be constructed with bottoms, or bottoms may be poured in place once the catch basin is located. Loops of rebar or wire rope are cast into the body so that they can be used as lifting eyes (attachment points) for placement using a crane or backhoe. Concrete basins may have pipe openings pre-cast into them; otherwise, the openings are cut into them after they have been set in place.

Smaller plastic catch basins, both round and square, (Figure 3), are available at most home improvement retail stores and plumbing wholesalers. They are of light duty construction and are widely used for residential landscaping in areas where there is no possibility of vehicular traffic on them.

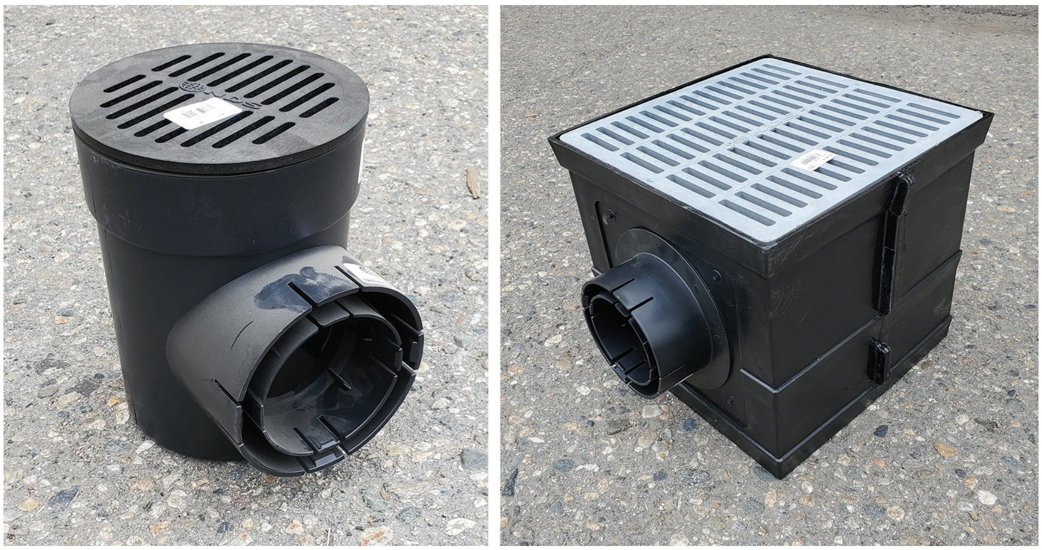

Figure 3 *Round plastic residential catch basin. (Skilled Trades BC, 2021) Used with permission.*

Drainage Troughs

Drainage troughs are another form of catch basin (Figure 4). They can be as long as needed and are fairly narrow. They are usually installed across driveways that are lower in elevation at the end nearest the building than at the street. They are preferred where water must be intercepted as it flows across a wide plane of sloped pavement or concrete rather than through a round or rectangular grate that has the area surrounding it graded to its central location. Water that would otherwise flow down the driveway and into the building is instead directed into the trough drain and carried away to the storm drainage system.

Figure 4 *Trough or trench drain in front of garage. (Skilled Trades BC, 2021) Used with permission.*

Trough or trench drains, as they are sometimes called, are constructed of either poured-in-place concrete or high strength plastic and have a narrow removable grate at the top where the runoff water enters. They are typically very shallow, and because of their limited depth, there is no downturned 90° elbow. Instead, the horizontal pipe outlet is located an inch or two above the bottom of the trench body (Figure 5). This allows a small amount of vertical space below the outlet's invert in which any sediment can be held back and accumulate. Accordingly, due to its limited sediment storage capacity, a trough or trench drain must be cleaned out more frequently than a catch basin.

Figure 5 *Plastic trough drain. (Skilled Trades BC, 2021) Used with permission.*

Catch Basin Operation

A catch basin's purpose is to allow surface runoff to drain while preventing sediment and debris from being carried out into the storm drainage system. This is accomplished by using a downturned 90° elbow and having some significant depth below it.

A cross-section of a typical heavy-duty concrete catch basin, such as what might be found in a parking lot, is shown in Figure 6. Notice that any sediment and debris carried through the drain grate with the runoff will settle and accumulate at the bottom of the basin. Once the depth of the sediment is sufficient, the drain grate is removed and the sediment can either be "mucked out" with hand tools or vacuumed out using a "jet vac" style of truck. Most catch basins are designed with at least a foot or more of liquid depth to allow sediment to accumulate while reducing the frequency of cleanings.

The liquid depth of a catch basin is measured between the bottom of the basin and the invert of the pipe leaving the basin. A key to trouble-free operation of catch basins is the use of a downturned 90° elbow with a short length of pipe extending into the liquid. This arrangement allows the water in the basin to drain while preventing anything that floats on the water's surface from being carried into the pipe. Some catch basins have a manufactured version of the elbow cast-in-place so that the installer only needs to connect the pipe to the outlet.

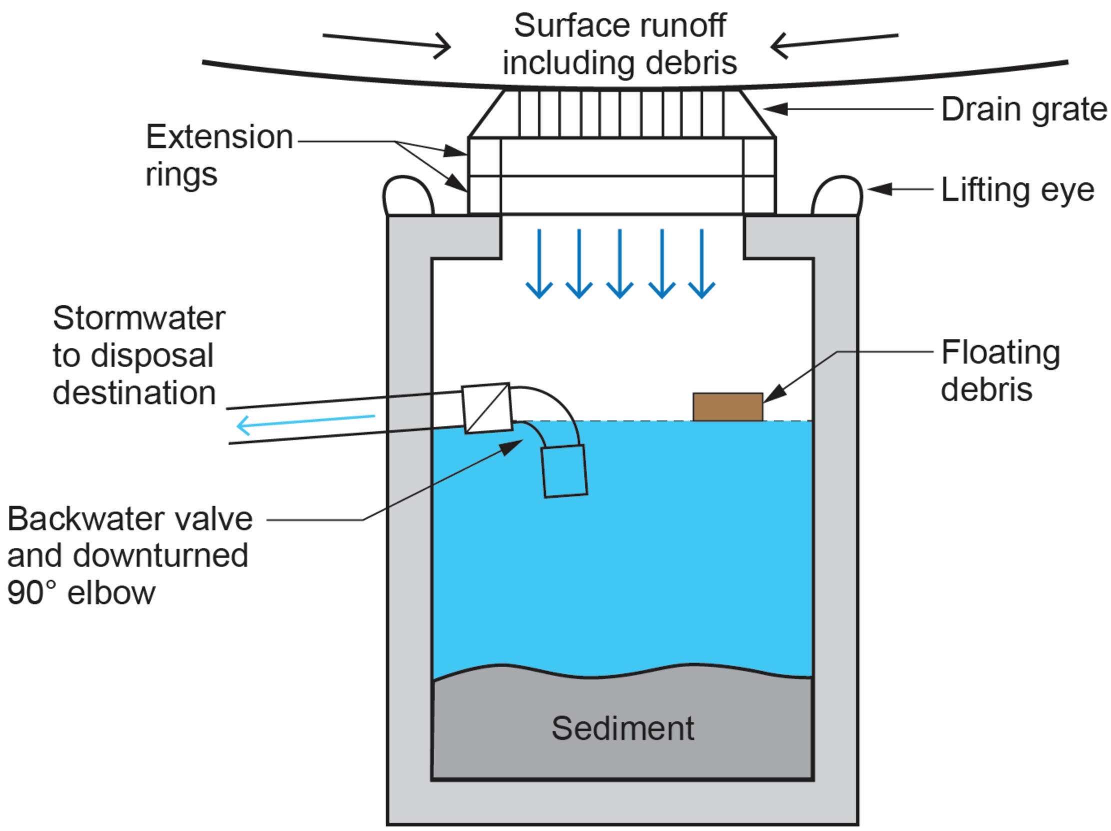

Figure 6 *Catch basin cross-section. (Skilled Trades BC, 2021) Used with permission.*

Catch basins may have a backwater valve installed downstream of the 90°. The intent of the backwater valve is to help prevent any surcharge (reverse flow) from coming back through the discharge piping into the catch basin and flooding the area. Backwater valves commonly have a rubber seal to allow them to close tight, but if the valve is not checked and maintained, it may not prevent reverse flow, and its installation may be ineffective.

In areas with dedicated storm sewers, the water from catch basins is carried through underground pipes to local streams, ditches, and other acceptable places of disposal instead of being taken to the sewage treatment plant along with household and industrial wastewater, as it is in a combined system. If the eventual discharge destination is a fish-bearing body of water, most AHJs will inform the public of the sensitivity to that environment by painting an icon of a fish on the concrete or paved surface adjacent to it. Some manufacturers now cast environmental warnings into their drain grates, as seen in Figure 7. These endeavours are meant to dissuade the public from allowing contaminants to enter the system and affect the environment.

Figure 7 *Catch basin grate with environmental info and fish icon. (Skilled Trades BC, 2021) Used with permission.*

Installation

When installing a concrete catch basin, a hole is dug and the ground beneath its intended location is levelled and compacted. The basin is set into place and levelled. The drain grate is set to elevation using extension rings of varying thickness grouted to the basin's top. The piping outlet elevation is determined and, if no pre-cast pipe opening has been provided, the wall of the concrete basin must be broken into using percussion tools and hammers. Any interior rebar or wire mesh is cut out of the way, the pipe is inserted into the new rough opening, and the penetration is sealed with grout.

Sumps

A sump differs from the definition of a catch basin in that a sump is usually a catch basin that cannot be drained by gravity because of its location and, therefore, needs to be pumped out. As well, sumps usually do not have an open drain grate on their top. They are sealed chambers with pipe inlets at either the top, sides, or both.

Sumps can be used for either stormwater or sanitary waste. An example of a storm sump would be one that is installed in the lowest level of an underground parkade in a large building. Discharge from all the floor drains for the parkade would be piped into the sump, and be pumped from there up into the storm building drain.

Using a sump for sewage is probably more common than for stormwater because there are many buildings where the lowest plumbing fixtures cannot drain by gravity if the building drain leaves the building at a higher elevation than that of the fixture drains. As well, sometimes a fixture, such as a clothes washer, needs to be located in an area where there is no roughed-in drainage piping. Rather than omit any fixtures in these situations, sewage sumps allow for fixture placement without possibly having to jackhammer into concrete floors. Fixtures drain by gravity into the sump, and sump pumps lift the sewage and discharge it into the sanitary building drain.

Regulations

Regardless of the contents of the sump (storm or sanitary), the National and BC Plumbing Codes address the installation of sumps in Article 2.4.6.3. Listed below are those code clauses.

2.4.6.3. Sumps or Tanks (See Note A-2.4.6.3.):

1. Piping that is too low to drain into a building sewer by gravity shall be drained to a sump or receiving tank.
2. Where the sump or tank receives sewage, it shall be water- and airtight and shall be vented.
3. Equipment such as a pump or ejector that can lift the contents of the sump or tank and discharge it into the building drain or building sewer shall be installed.
4. Where the equipment does not operate automatically, the capacity of the sump shall be sufficient to hold at least a 24-hour accumulation of liquid.
5. Where there is a building trap, the discharge pipe from the equipment shall be connected to the building drain downstream of the trap.
6. The discharge pipe from every pumped sump shall be equipped with a union, a backwater valve and a shutoff valve installed in that sequence in the direction of discharge.
7. The discharge piping from a pump or ejector shall be sized for optimum flow velocities at pump design conditions.

Note: A-2.4.6.3. from the codes shows a typical sump piping configuration, as replicated in Figure 8.

Note: The sump is receiving discharge from a "**sub-drainage system**." Although no definition exists, a sub-drainage system is widely held to be any piping that carries liquid waste that is too low to drain by gravity to a building drain and, therefore, must be drained into a sump.

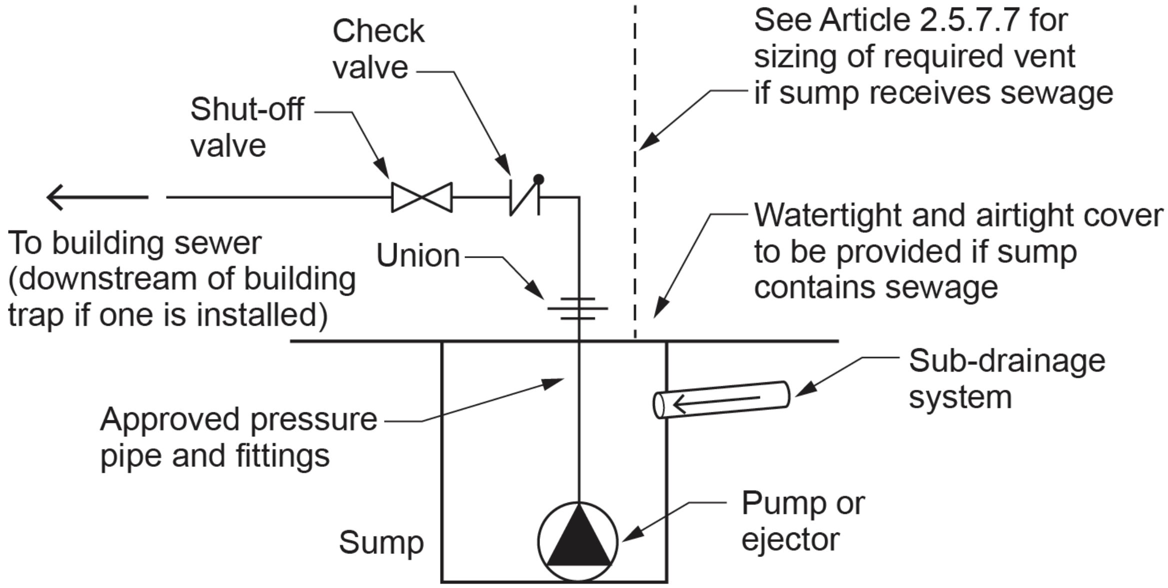

Figure 8 *Note A-2.4.6.3 arrangement of piping at sump. (Skilled Trades BC, 2021) Used with permission.*

In large commercial settings, sumps are either cast-in-place (formed and poured in concrete) or constructed of large sections (rings) of pre-cast concrete. The rings are stacked one onto another, with the seams grouted to make them watertight. A level floor is poured and made ready for pumps to be installed on them. Pre-cast sumps are also an option if of a smaller size.

The pumps and related controls and piping are installed so that the system works automatically. There is provision in the codes for a sump to have it be pumped out as part of a building operator's daily routine (see Subclause 4 above), but the sump would have to be sized to hold at least a 24-hour accumulation of liquid. This usually translates into a very large sump, and so the preference is for automatic control.

In large installations, the system is usually **duplex**, meaning that there are two pumps in the sump, each with its own union, check valve, and shutoff and piped in parallel. A series of **float switches** on electrical cord are suspended inside the sump. They are wired to a control panel that operates the pumps.

Sump Operation

Figure 9 shows four float switches, all at different levels, controlling two pumps. As the liquid level rises in the sump, the lowest switch starts to tip upward. A heavy lead weight is attached to the electrical cord just above each float to ensure that the float will be inverted vertically when the liquid level rises above it. At this point, the lowest float switch (#1) being inverted will not cause anything to occur.

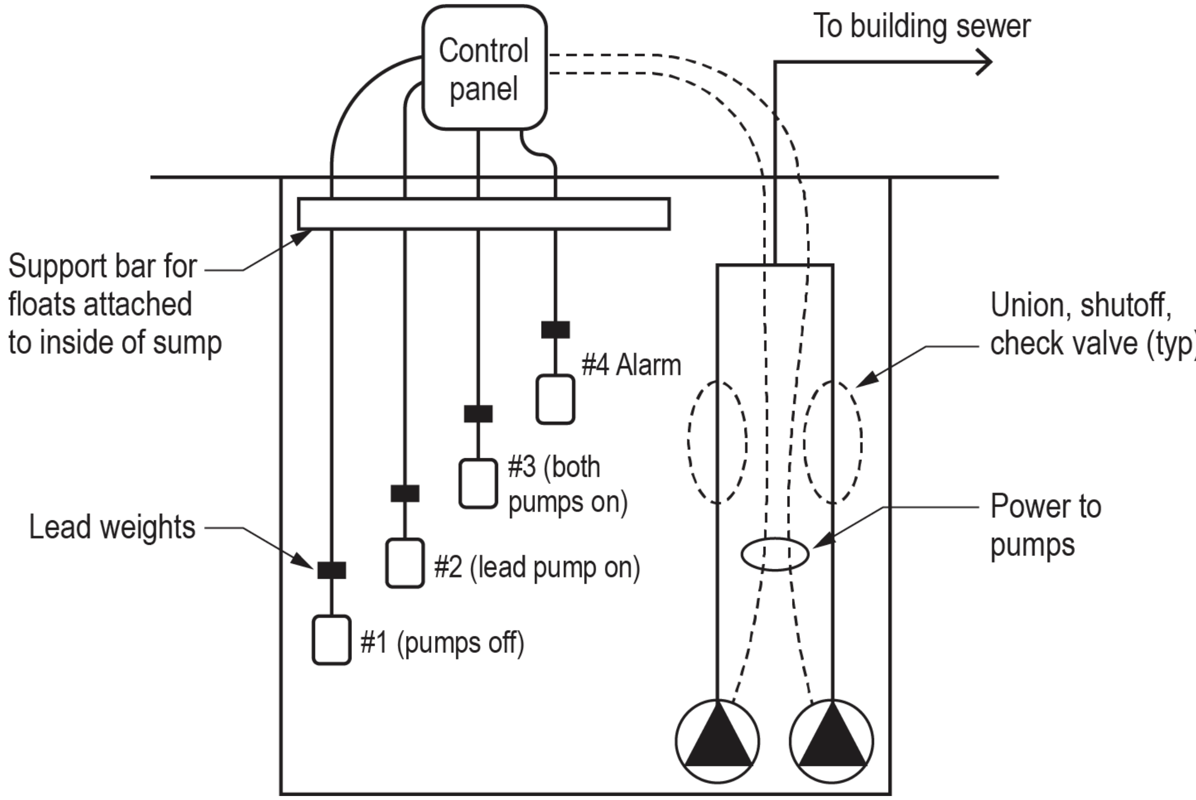

Figure 9 *Duplex sump pump system. (Skilled Trades BC, 2021) Used with permission.*

As the liquid level rises, float switch #2 tips upward. When the float is almost fully inverted, a switch inside it "makes" or closes, which sends a signal to the control panel. The control panel sends power to one of the two pumps, which turns on and starts to pump the liquid out through the piping to the building sewer. As the liquid level drops, float switch #2 hangs vertically again, but the pump continues to run. The pump will continue to operate until float switch #1 hangs vertically, at which point the switch contacts inside it "break" or open, and the pump shuts off.

Through normal operation, as the liquid level in the sump rises and falls, the control panel will operate the same pump on and off, while the other pump is on standby as a backup. This is known as "lead-lag" control. If desired, micro-switches inside the control panel can be configured so that the pumps take turns with normal operation. This is known as "alternating control."

Float switches #3 and #4 come into play in situations where, due to excessive inflow or possibly a pump that has malfunctioned, the liquid level continues to rise. If float switch #3 inverts, the control panel will power both pumps. In that way, if the lead pump has malfunctioned during normal inflows, the lag pump should be able to handle the flow and pump down the sump. If the lead pump cannot handle the excessive inflow, then both pumps should be able to pump down the sump. This is assuming, of course, that the pumps have been sized correctly.

If the liquid level gets to the point where float switch #4 is inverted, the control panel will sound a local alarm and possibly remote alarms as well.

Rather than have a horizontal support bar with a lead weight above each float, another option for installing the floats is to fix a small-diameter vertical pipe — made of galvanized iron, copper, or some other corrosion-resistant material — inside the sump (Figure 10). The cords of the float switches are taped or "zap-strapped" to the pipe a few inches above each float and one above the other. This negates the use of the lead weights while still allowing the float to tip upside down.

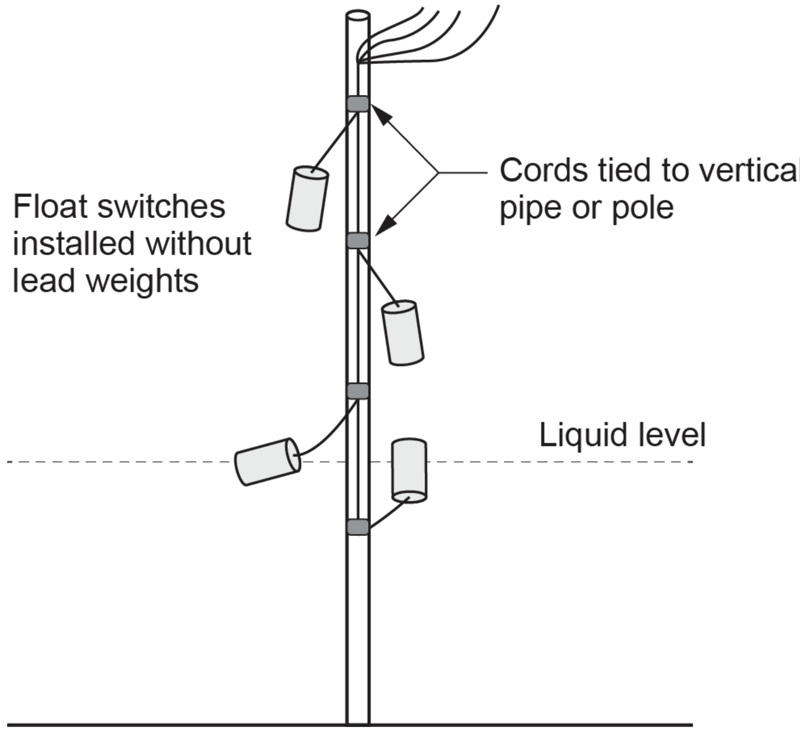

***Figure 10** Float tether pipe. (Skilled Trades BC, 2021) Used with permission.*

Cylindrical float switches will not “make” if the float does not invert. Without either a lead weight or the cord being tied off, the float switch will float in a horizontal orientation and will not engage the switch (Figure 11).

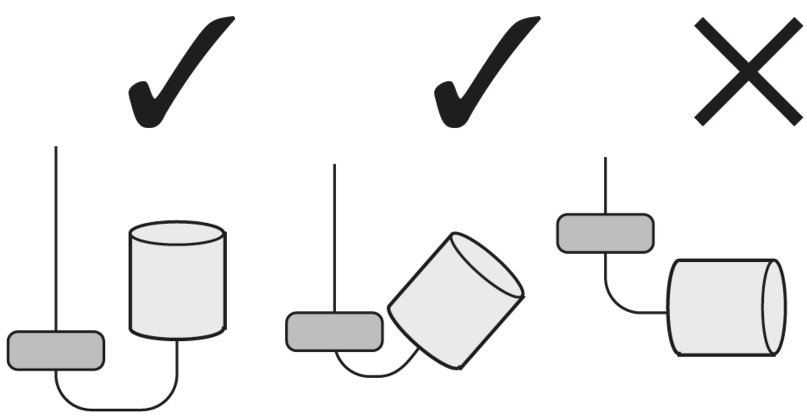

***Figure 11** Float switch orientation. (Skilled Trades BC, 2021) Used with permission.*

Sump Pump Installation

Small sump pumps, with outlet diameters two inches or less, are relatively easy to set into and pull from a sump. Cast-iron pumps three inches and larger are very heavy, and so there are support systems on guides and rails available to make installation, operation, and removal much easier.

Figure 12 shows a pump that only has to be winched in and out of the sump using lifting equipment. There are no electrical or piping connections in the bottom of the sump that need to be accessed to allow the pump to either be placed or removed. A cast-iron base with one or two vertical rails is bolted to the floor of the sump, and the rails are bolted to the inside of the sump near its top. The pump is mounted on a yoke that slides down the vertical rails to where it rests against the base. A hinged pipe connection, using rubber rings for sealing the yoke to the base, and flexible power supplies allow the pumps to be set in place or lifted out of the sump where they can more easily be worked on. Pumps used in large commercial installations are commonly high-voltage three-phase models.

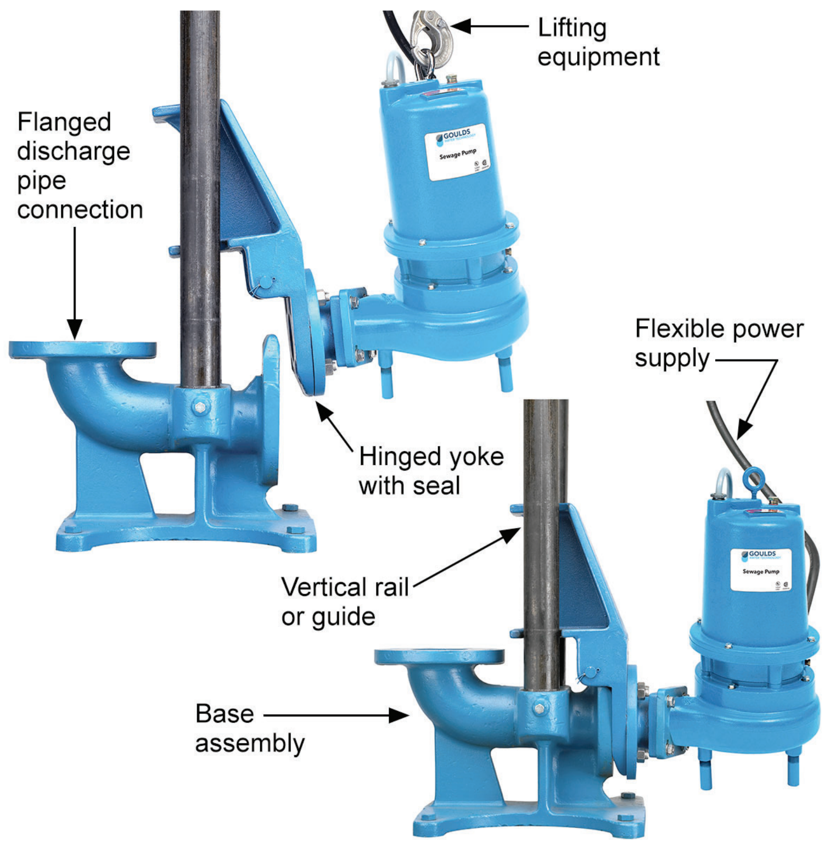

***Figure 12** Large-diameter sump pump installation on rails. (Skilled Trades BC, 2021; original from Xylem Canada, n.d.) Used with permission.*

Small packaged sump kits are commonly used in residential settings for basement bathrooms and laundries where the building drain is installed above the basement floor. A plastic tank with a sealed lid is furnished with a single submersible pump that is operated with a single float switch (Figure 13). The float switch is duplex in that it turns the pump on when inverted and off when back to its normal "hanging" position. There is a single inlet into the side of the tank, and the lid has openings for the discharge pipe, a vent, and a power cord.

Figure 13 *Plastic sumps. (Skilled Trades BC, 2021) Used with permission.*

The lid and all the openings have rubber seals to make the sump package water- and airtight. If the drainage piping is below floor elevation, the sump can be recessed and embedded (Figure 14).

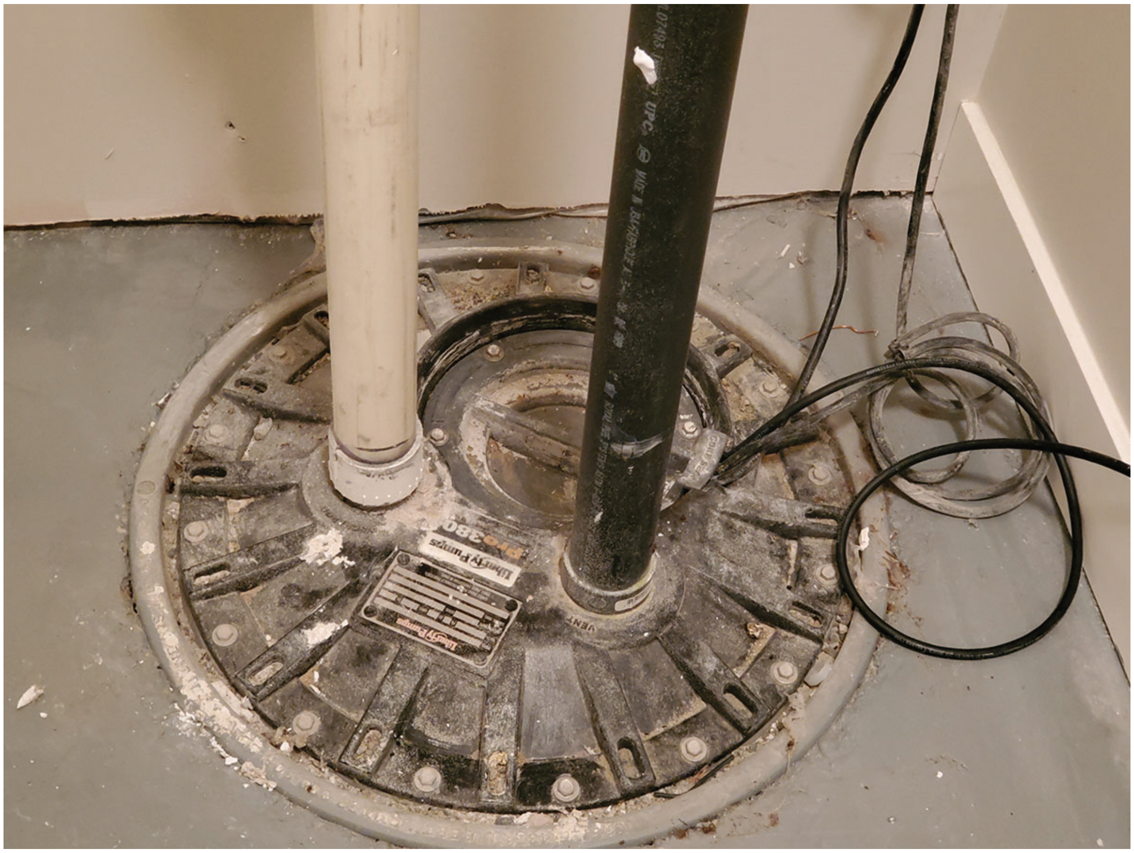

Figure 14 *Installed recessed and embedded sump. (Skilled Trades BC, 2021) Used with permission.*

If the fixture to be drained does not need to have buried piping, then an above-ground model of sump kit can be installed. In a laundry room, the clothes washer and laundry tub are drained through piping located above grade, so a plastic packaged sump can be installed on the floor near the fixtures. It will have either a side or top inlet, or sometimes both. Just like the recessed models, the removable lid will have openings with rubber seals for the discharge pipe, vent, and power cord (Figure 15).

Figure 15 *Above-grade sump kit for laundry fixtures. (Saniflo, 2021) Used with permission.*

Due to their limitations for placement, most above-ground sump kits have a capacity of only a few gallons, while below-ground models can be as large as desired. A common size for below-ground sump basins is 18 in. diameter by 32 in. deep, which would have a capacity of approximately 30 imp gal. Their pumps would have longer standby and run times than their smaller above-ground counterparts and should, therefore, have a longer life.

Any equipment that starts and stops frequently is more prone to wearing out and requiring service than that which operates less frequently and for a longer period. Access to above-ground sump pumps is normally easier than for below-ground units.

Some models of toilets are manufactured to be both a fixture and a sump (Figure 14). Known as "macerating toilets," they are rear-discharge to a sump that also has openings on either side to accept drainage pipes from bathtubs, showers, and basins. The upside to these styles of toilets is that they and the accompanying fixtures can be installed in basements without the need to break up concrete flooring.

Figure 16 *Above grade. (Saniflo, n.d.) Used with permission.*

The downside is that the drainage from the other fixtures is also above grade and may need to be exposed. As well, bathtubs and showers usually need to be installed on raised platforms in order to get their drainage piping high enough to connect to the macerating toilet's sump inlets. If aesthetics is a major consideration, then the installation of a below-ground sump is the better choice.

The electrical power needed for most above or below grade sump pumps is of the common household variety, which is single-phase, 120-volt alternating current supplied through a standard three-prong plug receptacle.

Self Test D-3.6: Sumps and Catch Basins

Complete Self Test D-3.6 and check your answers.

If you are using a printed copy, please find Self-Test D-3.6 and Answer Key at the end of this section. If you prefer, you can scan the QR code with your digital device to go directly to the interactive Self-Test.

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://d-drainagesystems-bcplumbingapprl2.pressbooks.tru.ca/?p=81#h5p-28 (https://d-drainagesystems-bcplumbingapprl2.pressbooks.tru.ca/?p=81#h5p-28)

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- **Figure 12:** Large-diameter sump pump installation on rails (https://www.xylem.com/en-ai/brands/goulds-water-technology/products/all-products/guide-rails-3-and-4/) from Xylem Inc. (n.d.) was adapted by Skilled Trades BC (2021) and used with permission from Xylem Canada, LLP. (https://www.xylem.com/en-ca/)
- **Figure 15:** Above-grade sump kit for laundry fixtures (https://www.saniflo.ca/us/blog/-four-affordable-value-adding-home-improvements-real-estate-agents-suggest-n292) from Saniflo was adapted by Skilled Trades BC (2021) and used with permission.
- **Figure 16:** Above grade (https://www.saniflo.com/us/installing-an-additional-bathroom/68-saniaccess-3.html) from Saniflo was adapted by Skilled Trades BC (2021) and is used with permission.

D-3.7 Sub-Soil Drainage Systems

Soil stability contributes to the integrity of building structures and public recreational areas as well as to slopes and landscapes that abut highways, subdivisions, septic systems, retaining walls, and the like. Natural soil conditions can vary greatly, and accordingly, their ability to hold or shed water will also vary greatly. The installation of subsoil drainage is often only considered after problems arise, and mitigating any such problems is usually far more expensive, disruptive, and time-consuming than if tackled as a process in the original planning of a project.

Hydrology – from Greek hýdōr meaning "water" and lógos meaning "study" — is the scientific study of the movement, distribution, and management of water on Earth and other planets, including the water cycle, water resources, and environmental watershed sustainability.

"Hydrologic" or "hydrological" engineers belong to a broad range of engineering technologies known as "**civil engineering.**" Their studies and findings have been widespread, well-documented, and full of terminologies that the average journeyperson may find hard to understand. Fortunately, most hydrologic-based information that the average plumber deals with is contained within jobsite blueprints, specifications, and applicable code books and is presented in a manner intended to be deciphered by non-engineers.

Purpose

Water contained within the soil can cause many problems, such as foundation collapse, sinkholes, mudslides, and other such catastrophes. While predicting such events may not be within the scope of a plumber's responsibilities, the use and application of sound industry principles and practices that an average plumber is expected to display in order to prevent them is.

Within the National Plumbing Code of Canada (NPC) and the BC Plumbing Code (BCPC), a "subsoil drainage pipe" is defined as "a pipe that is installed underground to intercept and convey subsurface water." Although no official definition exists in any of the model codes used in building in Canada, the most commonly held definition of "subsurface water" is "water that exists below the ground level."

Typical Locations for Subsoil Drainage

One of the most critical and common instances of having to deal with subsurface water is in the placing of footing drains for a building. The composition of soil can vary greatly, and although the practice of pouring concrete **footings** on rock or compacted granular fill may deter the retention of water below the footings, the act of installing a subsoil drainage system around the footings is widely accepted as the norm for all footing placements.

Regulations

The BC Building Code (BCBC), Sentence 9.15.3.2 (1) states, "Footings shall rest on undisturbed soil, rock or compacted granular fill."

Section 9.14 of the BCBC specifies requirements for surface and subsurface drainage. Sentence 9.14.1.2(1) states, "Drainage for crawl spaces shall conform to Section 9.18", and Sentence 9.14.1.3(1) specifies that "Drainage requirements beneath floors-on-ground shall conform to Section 9.16." The following points covered will be limited to those found in Sections 9.14.2 to 9.14.6, which focus on foundation wall drainage (9.14.2), drainage tile and pipe (9.14.3), drainage disposal (9.14.5), and surface drainage (9.14.6).

Subsoil Drainage for Building Footings

Subsoil drainage maintains the integrity of the ground under footings. By removing moisture, soil strength is stabilized, and the possibility of major foundation settlement is greatly reduced or eliminated entirely.

Sentence 9.14.2.1 (1) of the BCBC states "Unless it can be shown to be unnecessary, the bottom of every exterior foundation wall shall be drained by drainage tile or pipe laid around the exterior of the foundation in conformance with Subsection 9.14.3. or by a layer of gravel or crushed rock in conformance with Subsection 9.14.4."

BCBC Section 9.14.3.3 states that "**Drain tile** or pipe shall be laid on undisturbed or well-compacted soil so that the top of the tile or pipe is below the bottom of the floor slab or the ground cover of the crawl space." Figure 1 shows the standard installation for drainage systems around footings.

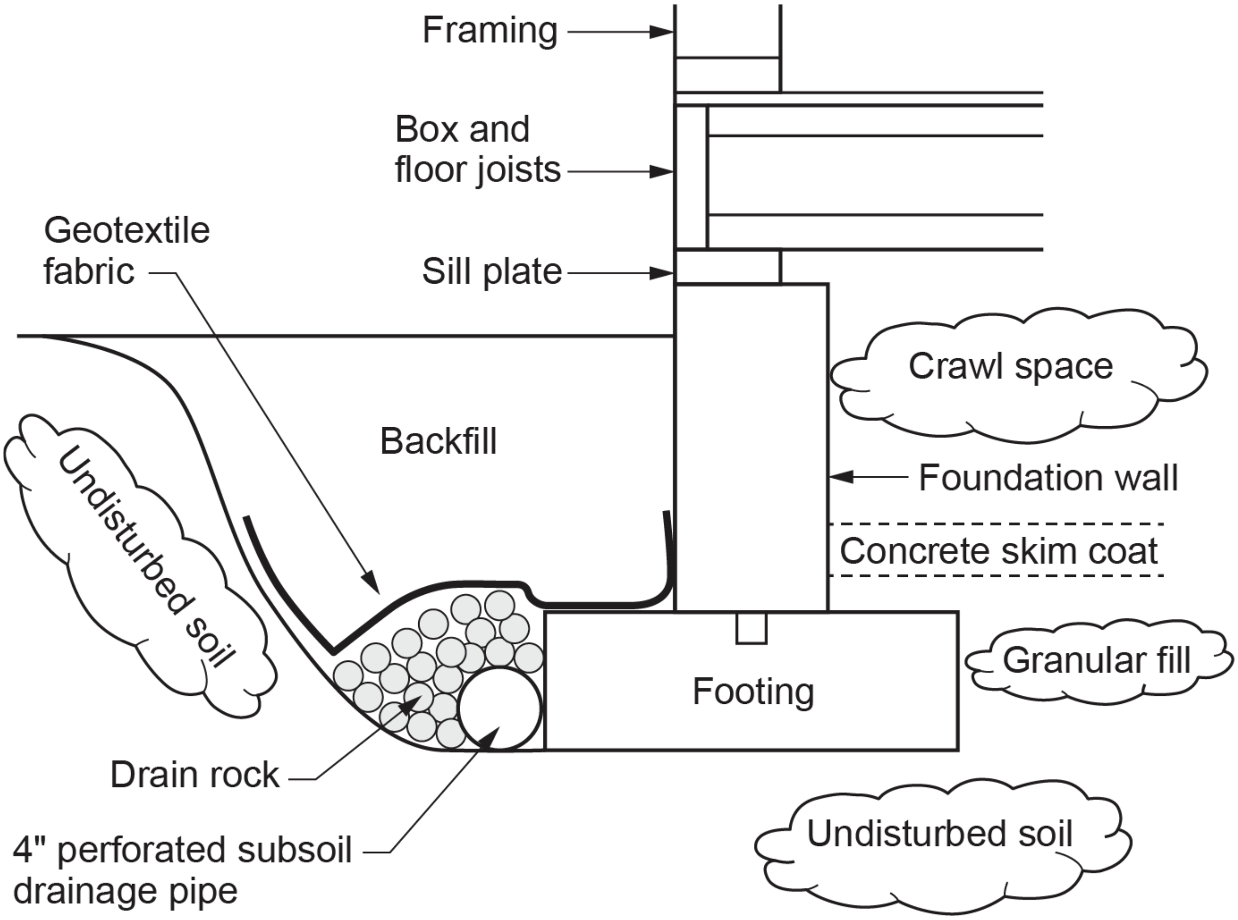

Figure 1 *Typical footing drain installation. (Skilled Trades BC, 2021) Used with permission.*

Although available in other sizes, 9.14.3.2. of the BCBC specifies "Drain tile or pipe used for foundation drainage shall be not less than 100 mm in diameter."

Although not specifically referenced in the codes, the backfill of a **perforated pipe** is protected from being plugged with fines and silt using a geotextile fabric (landscaping cloth or filter fabric) between the drain rock and backfill, as was shown in Figure 1. This practice is in use in virtually all instances where perforated pipe is installed underground.

Piping Materials

Subsection 9.14.3 of the BCBC lists the acceptable materials that can be used as drainage pipe — which are clay, concrete, plastic, and corrugated steel — and the standards that they must be certified to in order to be acceptable for installation. Of these, plastic is today's material of choice for most subsoil drainage applications.

Drain Tile

"**Drain tile**" refers to a type of pipe that, although still found in place, has been replaced by perforated plastic pipe. Subsequent to the use of wood stave piping but before the development of cast-iron pipe, clay was formed into pipe lengths and fired in kilns to become vitrified (hard and glass-like) and, as such, was known as "**vitreous clay pipe**" (Figure 2). It was heavy, brittle, and very corrosion-resistant. Its main uses were in acid waste systems and in subsoil systems.

Figure 2 *Clay pipe. (Tesamoll/Wikimedia Commons) CC0 1.0 (https://creativecommons.org/publicdomain/zero/1.0/deed.en)*

For subsoil systems, 3 in. or 4 in. diameter clay pipe (Figure 3) was formed into short lengths (tiles) of between 8 in. and 12 in. in length that often had an octagonal outer profile.

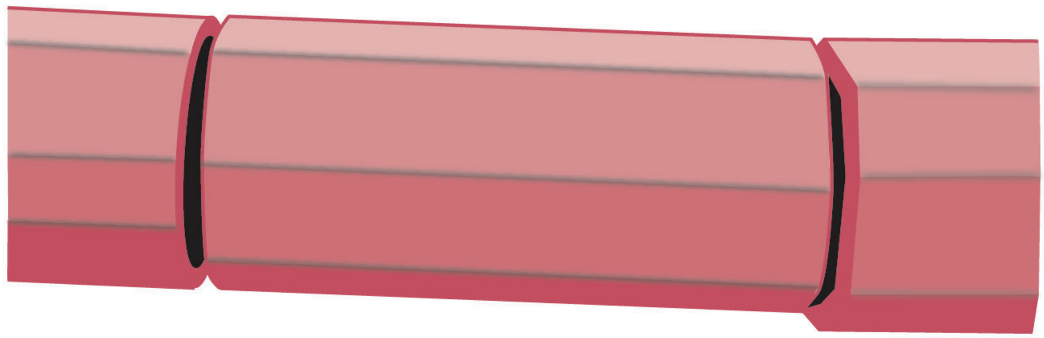

Figure 3 *Clay tile pipe for subsoil drainage. (Skilled Trades BC, 2021) Used with permission.*

The short lengths were laid end-to-end with a 0.25 in. to 0.50 in. space between them and covered with building paper or some other material to prevent the introduction of "**fines**" (small particles of dirt or silt) that would otherwise plug the openings. They were used extensively in sewage disposal fields and also to collect and channel away the water that might collect around footings until the advent of perforated plastic pipe. The terms "weeping tile" and "agriculture tile" were also given to this type of pipe because of the ways it was used.

Perforated Pipe

Clay tile pipe was replaced decades ago by **perforated PVC plastic pipe**. It is most commonly 3 in. or 4 in. in diameter and in lengths of either ten or thirteen feet. Although pipe is available that has perforations around its full circumference and length, the type most commonly used has two lines of 0.50 in. diameter holes spaced along the pipe's length 120° apart (Figure 4). The holes are positioned at the bottom of the pipe when being installed. The joints can be solvent-welded together, although leakage from the joints would be a redundant issue for most uses.

Figure 4 *Perforated PVC pipe. (Rod Lidstone)* CC BY (*https://creativecommons.org/licenses/by/4.0/deed.en*)

Corrugated Pipe

Another form of perforated plastic pipe is made of flexible corrugated polyethylene and is available in coils of 4 in. in diameter that are either 200 or 250 ft long (Figure 5). The perforations are quite small and so are more easily plugged by fines than PVC pipe. It is a common choice for agricultural applications where a constant even grade is not available.

Figure 5 *Four-inch corrugated perforated polyethylene pipe. (Greg Wirashowsky/Skilled Trades BC, 2021) CC BY (https://creativecommons.org/licenses/by/4.0/)*

Perforated polyethylene pipe is also available with the geotextile fabric pre-installed, as seen in Figure 6.

Figure 6 *Corrugated perforated pipe with fabric wrap. (Skilled Trades BC, 2021) Used with permission.*

Subsoil Drainage Discharge

Sentence 9.14.5.1 (1) of the BCBC specifies that "Foundation drains shall drain to a sewer, drainage ditch or dry well." Drainage to a sewer is expected to be accomplished by first dumping any footing drain discharge into a sump. In doing so, any debris is removed. The specifics of the sump construction for this application are found in Article 9.14.5.2 and are as follows:

1. Where a sump pit is provided it shall be:
   - Not less than 750 mm deep,
   - Not less than 0.25 m2 in area, and
   - Provided with a cover.
2. Covers for sump pits shall be designed:
   - To resist removal by children, and
   - To be airtight in accordance with Sentence 9.25.3.3.(7).
3. Where gravity drainage is not practical, an automatic sump pump shall be provided to discharge the water from the sump pit described in Sentence (1) into a sewer, drainage ditch or **dry well**.

A drainage ditch, as referenced in the code clauses above, is a common and acceptable termination point for most subsoil drainage systems. Many residential properties have ditches that abut the property line and are naturally used for such purposes.

In the absence of a drainage ditch, a dry well or rock pit can be used. It need not be anything more elaborate than an excavated hole in the ground filled with drain rock, into which the drainage pipe is inserted. The dispersal of water from it is more localized than would occur if using a horizontal trench and drain rock. Any discharge from the pipe is expected to percolate (seep) into the soil within a relatively small area. Dry wells may have a perforated tank or drum that acts as a reservoir to provide more volume of initial fill (Figure 7). Regardless of the type of reservoir chosen, it would have to be capable of supporting the ground above it.

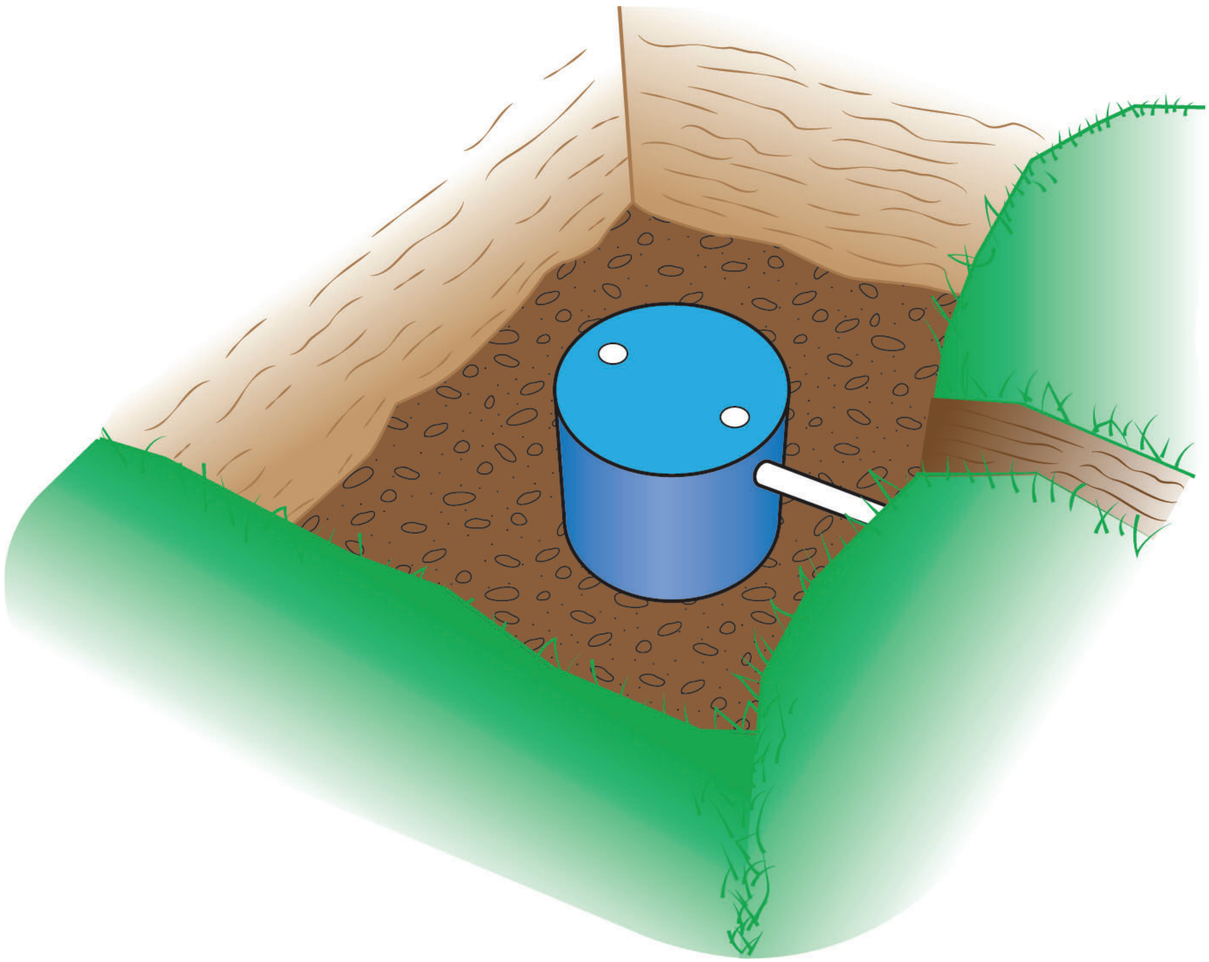

Figure 7 *Home-built dry well using perforated 45-gal plastic drum. (Skilled Trades BC, 2021) Used with permission.*

Many houses and buildings built in the latter half of the 20th century combined water from roof drains and eavestroughs with that from the footing drainage system. This was done primarily as a cost-saving measure. **Tees** were installed in the drain tile surrounding the footings at the locations where the vertical leaders or downspouts were to be located, and pipe was extended to just above ground level, where they connected to the bottom of the leaders. This method proved to be problematic, as the extra water from the leaders often found its way under the footing and into the building if the footing drainage system became restricted or plugged. This is no longer done. As seen in Figure 7, the roof drainage is directed into a separate system of watertight piping that encircles the building and usually discharges into the same termination point as the footing drain.

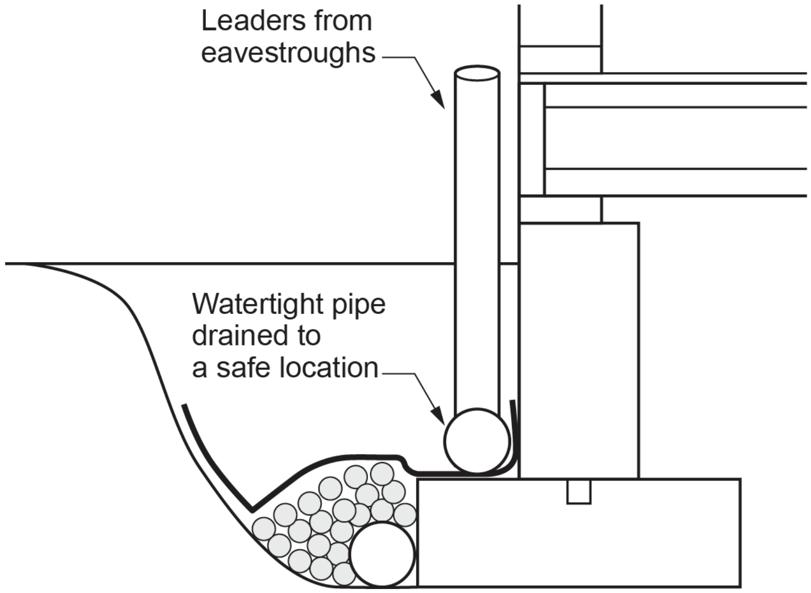

Figure 8 *Dedicated footing and roof drainage piping systems. (Skilled Trades BC, 2021) Used with permission.*

There are certain areas of the country where subsoil drains, such as from footings, are brought inside the building and tied into the sanitary drainage system. Sentence 2.4.6.4 (6) of the NPC and BCPC specify that the subsoil piping is to be protected from surcharge (backflow from the sanitary systems into the subsoil piping) by installing a gate valve or a backwater valve. This is illustrated in Note A-2.4.6.4 (6) of the code.

Other Subsoil Drains

There are many other types of subsoil drainage systems not covered in the building code because they are designed to control excess water on various landscapes, often for agricultural purposes, rather than for building protection.

French Drains

In 1859, in Concord, Massachusetts, a judge and farmer named Henry French developed an effective way to prevent surface water from ponding by collecting it and channelling it away. He published his concepts in a book with the exhaustive title of *Farm Drainage*; *The Principles, Processes, and Effects of Draining Land with Stones, Wood, Plows, and Open Ditches and Especially with Tiles*; *Including Tables of Rainfall, Evaporation, Filtration, Excavation, Capacity of Pipes, Cost and Number to the Acre, of Tiles, Etc., Etc.*

His concept was thereafter known as a "**French drain**" and is widely used to this day. There are numerous variations to his original idea, and modern materials have improved its functionality. In government publications in British Columbia, French drains are referred to as "blind inlets."

A French drain consists of a trench; perforated pipe; clean, washed rock; **geotextile fabric**; and backfill, as shown in Figure 9.

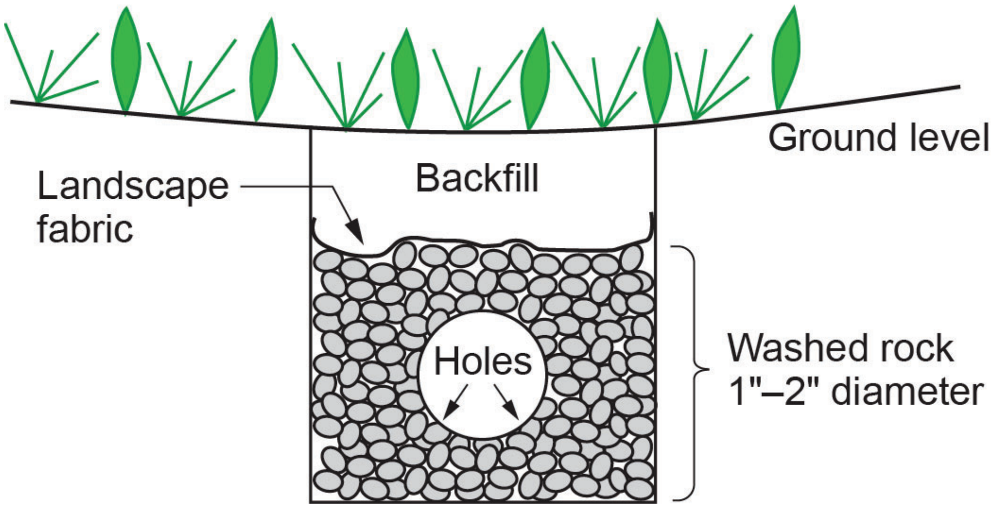

Figure 9 *Typical French drain. (Skilled Trades BC, 2021) Used with permission.*

A trench is dug approximately 8 in. (200 mm) wider than the width of the pipe and as deep as needed in order to have a reasonable amount of backfill above the landscape fabric separating the backfill from the rock. A minimum of 2 in. (50 mm) of washed rock is placed in the bottom of the trench below the pipe. The pipe is laid, and the trench is filled with washed rock to at least 2 in. (50 mm) above the pipe. Landscape fabric is laid on top of the washed rock, across the width of the trench, then the trench is backfilled. Note that the perforations (holes) are positioned at the bottom of the pipe.

A network of trenches can be installed in a few different configurations to provide coverage over large areas, as seen in Figures 10 and 11.

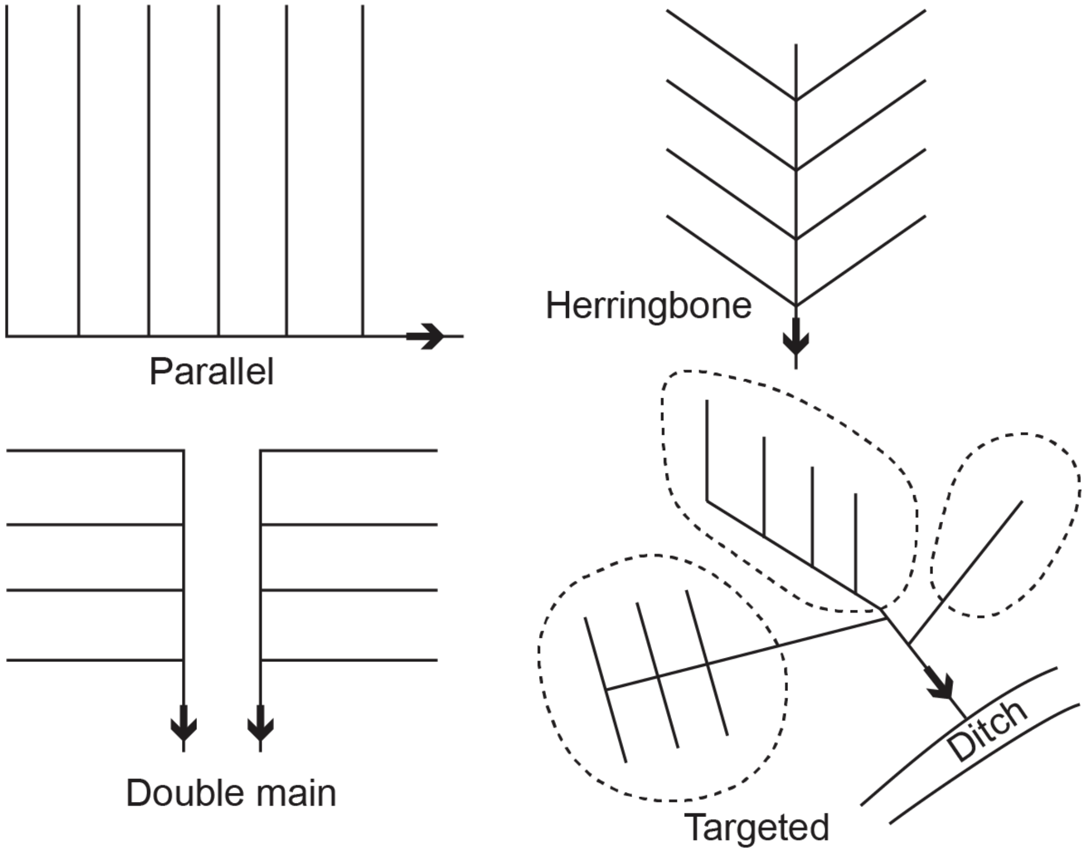

***Figure 10** Various drainage system layout alternatives. (Skilled Trades BC, 2021) Used with permission.*

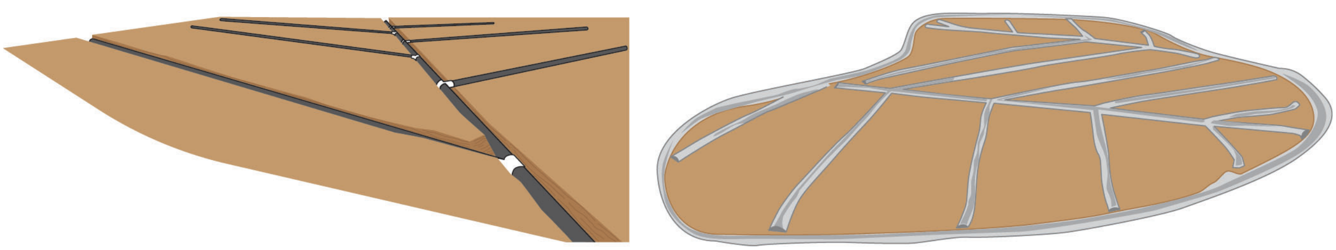

***Figure 11** Drainage trench examples. (Skilled Trades BC, 2021) Used with permission.*

Curtain Drain

Subsoil drains are typically installed at natural depressions in the ground, which is where ponding usually occurs. This minimizes the amount of sculpting that must be done to the surrounding area in order to direct surface water to desired locations for collection.

Curtain drains are French drains installed across a slope. Their purpose is to lessen the amount of water that might accumulate on a sensitive surface, such as the disposal field for a septic system, by intercepting and draining it away from the area. As seen in Figure 12, surface runoff is caught in a slight depression created by a buildup of soil on the downstream side of the trench. This is commonly called a **berm**. The berm holds back water that is allowed to percolate through the thin layer of topsoil into the trench below and be drained away to a more suitable location. Curtain drains lower the water table of the original topography.

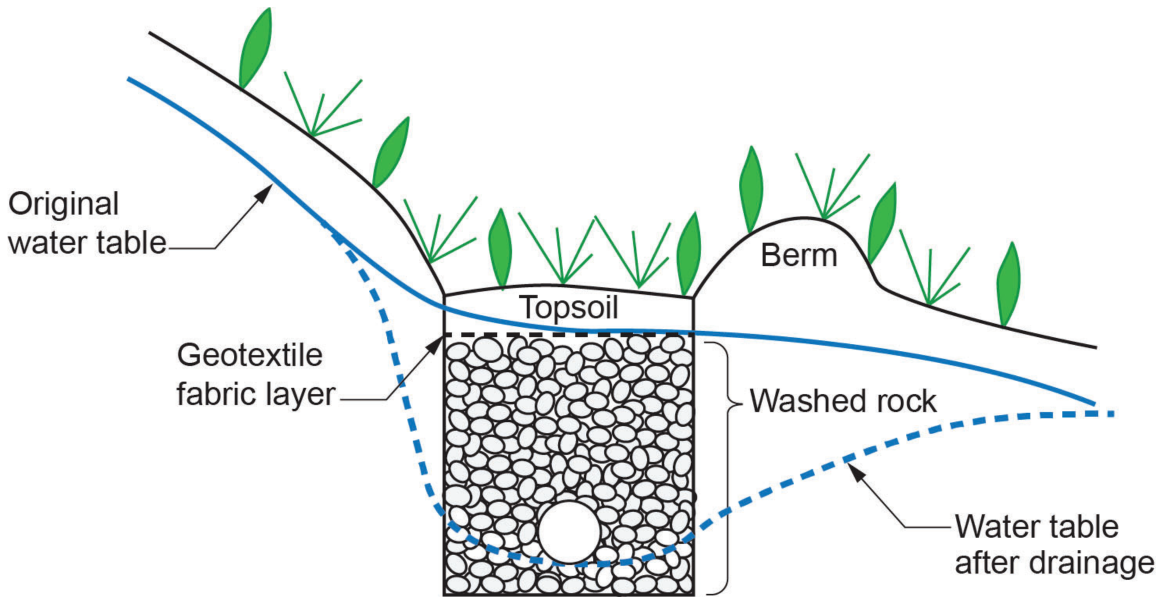

Figure 12 *Curtain drain. (Skilled Trades BC, 2021) Used with permission.*

Curtain drains are also beneficial when installed at the base of a slope of rock. Almost every drop of rain that contacts the rock face will make its way to the bottom of the slope, with virtually none of it being absorbed into the surface along the way. Ponding and flooding at the base of the slope could otherwise result. A curtain drain located near the slope's base can help mitigate any accumulation of water.

Mole Drains

"**Moling**" is a commonly used process in agriculture whereby a torpedo-shaped mandrel, with an expander/compacter behind it, is pulled through the soil behind a heavy tractor or bulldozer to create a void horizontal space or tunnel below ground. The mole assembly is at the bottom of a very narrow stem or beam that splits the ground cover without leaving a trench or depression. The equipment is often referred to as a "**trenchless plow**". Moling can be done with or without pipe being pulled simultaneously behind the expander/compacter into the trench.

Pipeless moling is most commonly used in farming. Soils with high clay content are problematic for farmers because they tend to hold water for great lengths of time once saturated (waterlogged) and have very slow percolation rates, which causes ponding of snow melt and rain in the shoulder seasons. Both situations are detrimental to crop production and can be alleviated by installing a pattern of "moled" channels that lead to a main French drain.

First, a main French or trench drain is installed through the field. Special equipment (Figure 13) is used to trench, install pipe, and drain rock all at the same time and to any chosen elevation below ground. These are normally installed at a recommended depth ranging from 900 mm (3 ft) to a maximum of 1.5 m (5 ft) with an average depth being 1.2 m (4 ft). These depths ensure the pipe will not be contacted by tillers or plows when the field is being cultivated.

Figure 13 *Installing a main French drain. (Skilled Trades BC, 2021; Western Australian Agriculture Authority) WAAA Copyright (https://www.agric.wa.gov.au/copyright)*

Next, a mole is pulled across the field in a grid pattern perpendicular to the main trench. The mole creates tunnels at an elevation that intersects the main trench just above the pipe (Figure 14). Groundwater enters the network or **mole drains** and follows them to the main trench drain. Discharge from the trench drain is directed to a natural waterway, such as a ditch or stream.

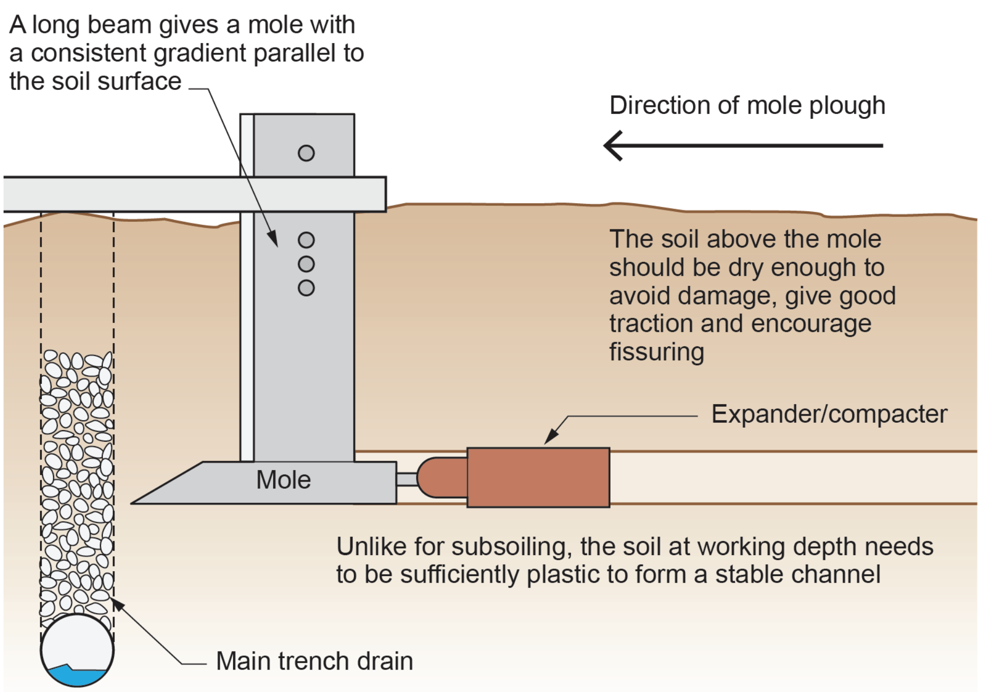

Figure 14 *Mole at work. (Skilled Trades BC, 2021) Used with permission.*

Self-Test D-3.7: Sub-Soil Drainage Systems

Complete Self-Test D-3.7 and check your answers.

If you are using a printed copy, please find Self-Test D-3.7 and Answer Key at the end of this section. If you prefer, you can scan the QR code with your digital device to go directly to the interactive Self-Test.

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://d-drainagesystems-bcplumbingapprl2.pressbooks.tru.ca/?p=83#h5p-29 (https://d-drainagesystems-bcplumbingapprl2.pressbooks.tru.ca/?p=83#h5p-29)

References

Skilled Trades BC. (2021). *Book 2: Install fixtures and appliances, install sanitary and storm drainage systems.* Plumber apprenticeship program level 2 book 2 (Harmonized). Crown Publications: King's Printer for British Columbia.

Trades Training BC. (2021). D-3: Install storm drainage systems. In: *Plumber Apprenticeship Program: Level 2*. Industry Training Authority, BC.

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- **Figure 2:** Clay pipe (https://commons.wikimedia.org/w/index.php?curid=12673988) by Tesamoll on Wikimedia Commons was used by Skilled Trades BC (2021) under a CC0 1.0 (https://creativecommons.org/publicdomain/zero/1.0/deed.en) license.
- **Figure 4:** Perforated PVC pipe by Rod Lidstone is used under a CC BY (https://creativecommons.org/licenses/by/4.0/deed.en) license.
- **Figure 13:** Installing a main French drain [Left image (https://www.agric.wa.gov.au/waterlogging/mole-drainage-western-australia), Right image (https://www.agric.wa.gov.au/sites/gateway/files/Bulletin%20-%204610%20Mole%20drainage%20for%20increased%20productivity%20in%20the%20south%20west%20irrigation%20area_0.pdf)] by the Western Australian Agriculture Authority was used by Skilled Trades BC ["for non-commerical educational purposes"] under WAAA Copyright (https://www.agric.wa.gov.au/copyright) terms and conditions.

D-3.8 Stormwater Site Retention Systems

Water evaporates from lakes, rivers, and oceans. It then becomes water vapour and forms clouds. It falls to the earth as precipitation and then evaporates again. This **hydrological cycle** never stops. Water keeps moving and changing phases from solid to liquid to gas, repeatedly. This process is described as the natural water balance. **Stormwater** is runoff generated by human development. It is created when land development alters the natural water balance and flow.

When vegetation and soils are replaced with roads and buildings, less rainfall infiltrates into the ground, less gets taken up by vegetation, and more becomes surface runoff. The biggest increments of change to the water balance in general — to the surface runoff component — occur when natural land is cleared and paved over. Environment Canada has estimated that urbanization of a natural drainage basin can increase stormwater **runoff** by 400% or more.

Until recently, the traditional approach to drainage has been to remove runoff as quickly as possible from developed areas. As a result, traditional urban design is very efficient in collecting, concentrating, conveying, and discharging stormwater to receiving waters. Runoff volume increases in proportion to impervious area (hard, non-absorbent surfaces). Traditional ditch and pipe systems have been designed to remove runoff from **impervious surfaces** as quickly as possible and deliver it to receiving waters. The resulting storm water arrives at the receiving waters much faster and in greater volumes than under natural conditions. This traditional grey infrastructure approach can cause flooding, loss of aquatic habitat, and water pollution in downstream receiving waters. Modern stormwater **source control** practices provide rainwater capture to reduce runoff volumes.

Stormwater Management Strategy

A stormwater management strategy seeks to mitigate the impacts of increased urban runoff and stormwater pollution by managing it as close to its source as possible.

The Local Government Act sets out specific provisions for planning, regulation, development approval, and servicing provisions applicable to storm water management, such as:

- Prohibition of pollution
- Soil deposit and removal (erosion control)
- Zoning
- Environmental policies
- Runoff control
- Landscaping
- Development permit areas
- Subdivision servicing requirements

In addition to the above, other municipal stormwater management powers can be found in provisions dealing with:

- Building regulations
- Contaminated sites
- Development cost charges
- Ditches and drainage
- Dikes
- Development works agreements
- Flood protection
- Farming
- Highways
- Improvement districts and specified areas
- Park land
- Regional district services
- Sewage systems
- Subdivision

- Temporary commercial and industrial use
- Tree cutting
- Utilities
- Water
- Waste management.

To achieve performance targets for rainfall capture, runoff control, and flood risk management, the targets must be translated into achievable design guidelines that developers and local government staff can understand and apply at the site level.

Reducing runoff volume is the key to achieving performance targets for rainfall capture. The following volume reduction strategies should be applied:

- Minimize the disturbance of natural soils and vegetation.
- Apply absorbent landscaping.
- Implement stormwater source control practices to capture runoff from impervious surfaces.

Minimize the Disturbance of Natural Soils and Vegetation

At the land use planning and site design levels, it is important to identify and preserve the natural areas that are most important to maintaining the natural water balance, such as wetlands, natural **infiltration** areas, and riparian forests. Low-impact site design practices that limit the creation of impervious area, the compaction of natural soils, and the clearing of natural vegetation should also be applied.

Apply Absorbent Landscaping

For landscaped areas, an absorbent surface soil layer should be provided. This absorbent soil layer should:

- Be deep enough to store the mean annual rainfall (24-hour duration).
- Meet the BC Landscape Standard for medium or better landscapes, which will ensure the type of hydrologic characteristics required for rainfall capture.

Stormwater Source Control Practices

Source control options include:

- Detention systems
- Retention/infiltration systems
- Green roofs
- Rainwater reuse

Detention or Retention

It is often difficult to identify the difference between the different types of stormwater control solutions because they use much of the same equipment, such as ponds, tanks, and infiltration chambers.

Detention systems are employed on a site to reduce the quantity of stormwater runoff leaving a site by temporarily storing the runoff that exceeds a site's allowable discharge rate and releasing or pumping it slowly over time, with little or no possibility of onsite infiltration.

The significant difference with a stormwater **retention system** is that it allows the water to slowly discharge into the soil instead of detaining it for a time before releasing it. This also helps to recharge the area's water table, which is something that runoff cannot do.

Underground stormwater retention and detention systems are a key component of reducing runoff in modern site development. Stormwater retention and detention systems are present in the industry as either above-ground ponds (Figure 1) or as subsurface storage and piping (Figure 2).

The use of ponds is the least expensive method, though it is the most inefficient use of developable land, is prone to siltation and clogging, and poses long-term aesthetic problems, such as insect breeding, weed growth, odour, and refuse issues. Whereas subsurface retention and detention systems use available land efficiently while introducing low maintenance costs and posing little or no aesthetic problems

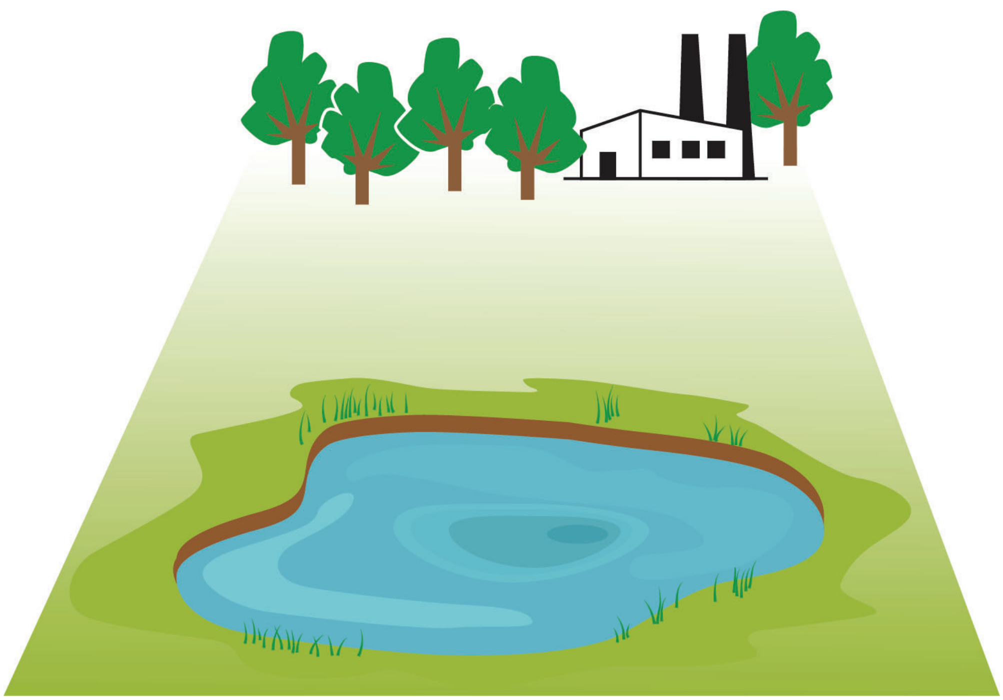

Figure 1 *Retention pond. (Skilled Trades BC, 2021) Used with permission.*

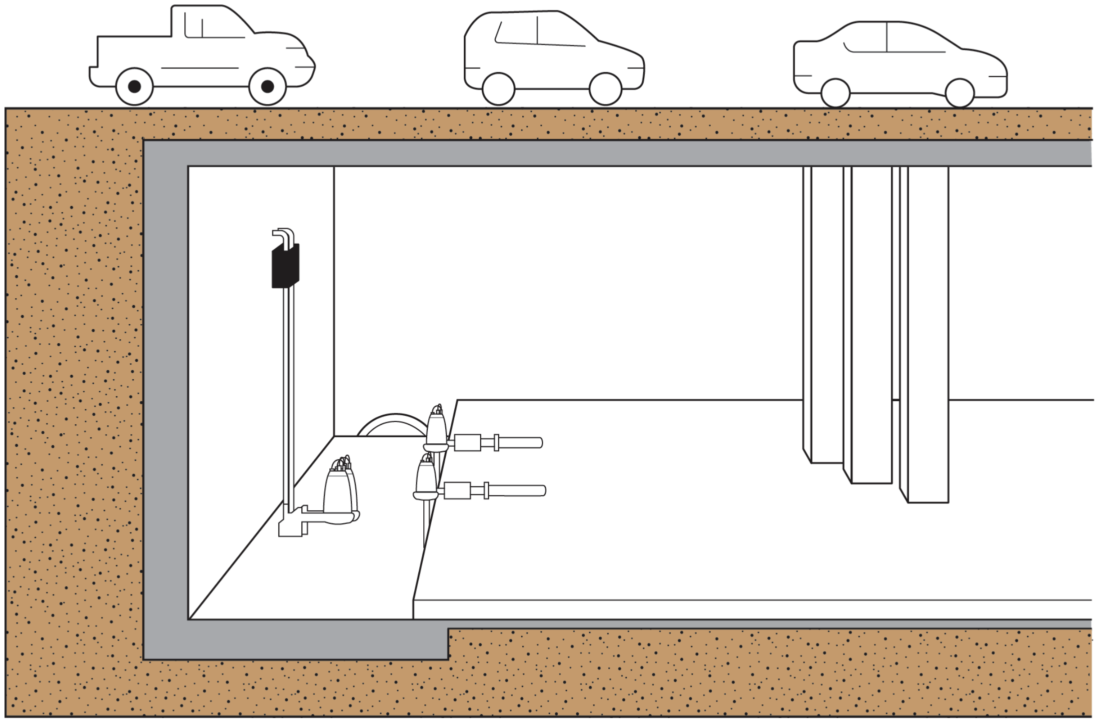

Figure 2 *Stormwater retention tank. (Skilled Trades BC, 2021) Used with permission.*

The components of these systems typically involve underground tanks, arches, or contained pipe systems in conjunction with geo-fabrics, filters, and aggregate layers. These systems are designed to help avoid the flooding and erosion that can be caused by excess runoff. With the integrated filtration elements, the discharged water will not have an adverse effect on streams, rivers, or wetlands and all the aquatic life they support.

Storage infiltration systems are incorporated into a retention solution to reduce the volume of stormwater runoff being discharged from a site. The infiltration system can consist of structurally reinforced chambers (Figure 3), vaults, crates, perforated pipes, or other void-forming structures embedded in coarse aggregate (https://wiki.sustainabletechnologies.ca/wiki/Reservoir_gravel).

Figure 3 *Arched infiltration chambers. (Arbitrarily0/Wikimedia Commons) CC BY-SA 3.0 (https://creativecommons.org/licenses/by-sa/3.0/deed.en)*

This runoff reduction strategy is a major part of a low-impact development design. Infiltration is likely the only way to achieve the target condition of restoring 90% of total rainfall volume to natural hydrologic pathways and is the most appropriate source control for single-family land uses, which is the dominant land use in most developed watersheds in most provinces. The level of reduction in the volume and rate of runoff achievable using infiltration depends on soil conditions, and therefore, soils information is key to the planning and design of infiltration facilities.

Because of the complexity of calculating target runoff discharge rates, site-retention systems for large developments (Figure 4) are typically designed by engineers and constructed by contractors to engineers' and local authorities' requirements. Design guidelines for systems serving single- family dwellings may be specified by local authorities due to their relatively low discharge rates. Rock pits and disposal fields, similar to those used in a septic disposal system, are most commonly used for small-scale runoff reduction. Using overflow piping to a discharge location ensures that the retention system does not back up and flood the property and equipment being served.

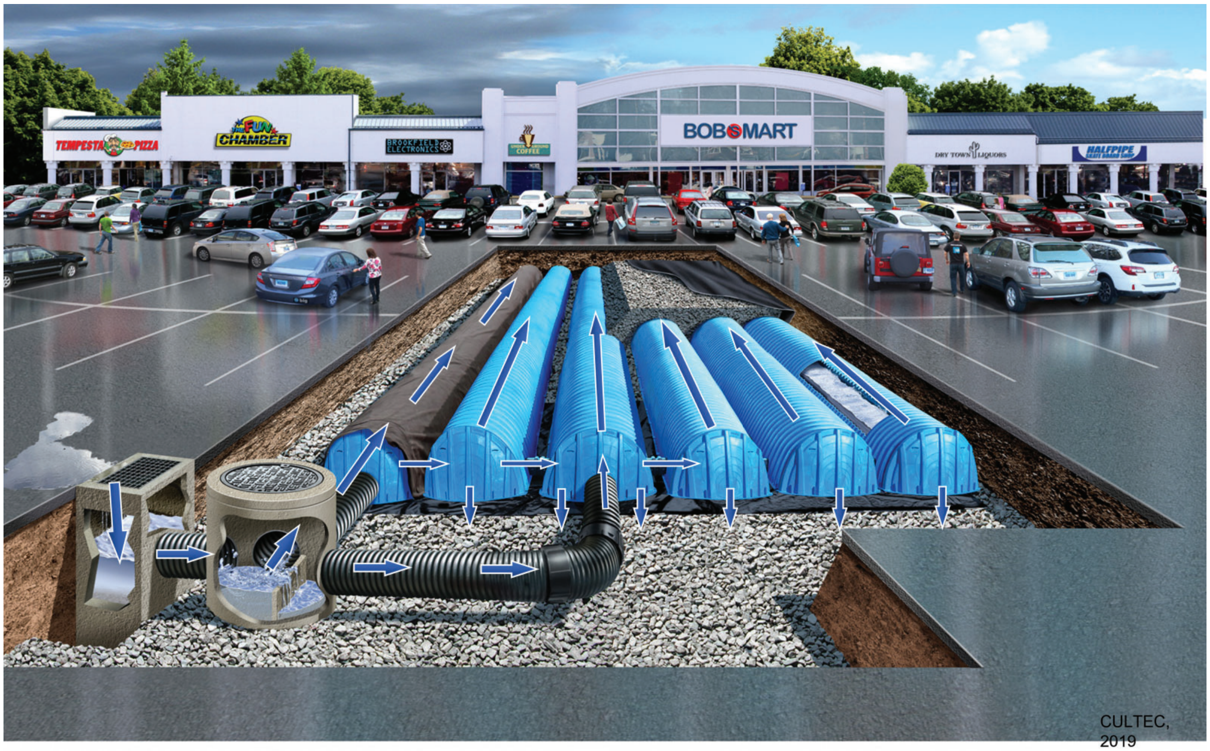

Figure 4 *Engineered stormwater retention system. (DanielFilippi/Sustainable Technologies Evaluation Program Wiki)* CC BY 4.0 *(https://creativecommons.org/licenses/by/4.0/)*

Green Roofs

The volume and rate of rooftop runoff can be reduced by installing absorbent landscaping on the rooftops of buildings or parkades. **Green roofs** (Figure 5) will store and provide evapotranspiration for rainfall from small events and will slow the rate of release of medium-sized events. Green roofs are most effective for land uses with high levels of rooftop coverage, such as multi-family and commercial land uses (especially with underground or structured parkades).

Figure 5 *Green roof. (Sky Garden Ltd/Wikimedia Commons)* CC BY-SA 4.0 (*https://creativecommons.org/licenses/by-sa/4.0/deed.en*)

A storage layer of perforated plastic or drain rock under the green roof soil can increase the effective rainfall capture and storage volume. The drainage outflow from the green roof should be connected to infiltration facilities in suitable areas of the site with an overflow to the storm drain system. Runoff from roof water should be kept separate from paved surfaces runoff, which can be polluted with hydrocarbons and heavy metals. Whereas paved surface runoff may require treatment, most green roof runoff will be clean enough to be released directly to storage and receiving waters.

Drain inlets from green roofs will require regular inspection. Watering may be required, using either surface standard watering devices or an automatic irrigation system.

Rainwater Reuse

Capturing and reusing rooftop runoff for **greywater** uses (e.g., toilets and laundry) or for irrigation can reduce runoff volume. The opportunities for runoff volume reduction through reuse are most significant for high-density residential and commercial land uses with high water usage.

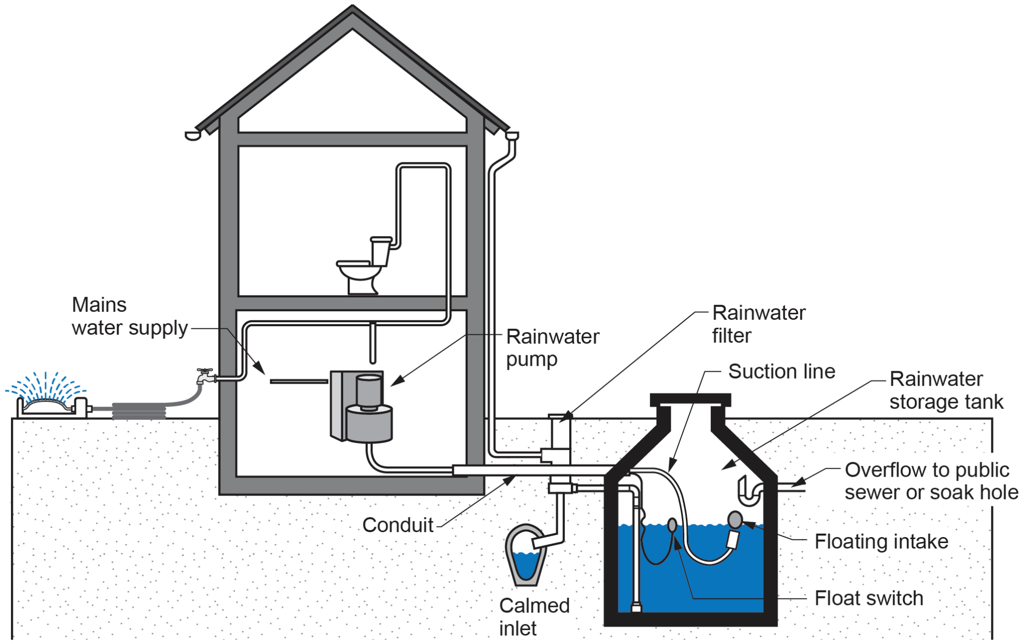

Figure 6 *Rainwater reuse system. (Skilled Trades BC, 2021) Used with permission.*

The benefits of **rainwater reuse** go beyond stormwater management in that reuse can also reduce the amount of water drawn from reservoirs and reduce the costs of water supply infrastructure.

Summary

Because there are many types of stormwater control solutions being applied in different regions, it is important to check with local building inspection departments for any regulations regarding site stormwater handling.

You can also find additional information in publications such as Storm Water Planning: A Guidebook for British Columbia (https://www2.gov.bc.ca/assets/gov/environment/waste-management/sewage/stormwater_planning_guidebook_for_bc.pdf).

Self-Test D-3.8: Stormwater Site Retention Systems

Complete Self-Test D-3.8 and check your answers.

If you are using a printed copy, please find Self-Test D-3.8 and Answer Key at the end of this section. If you prefer, you can scan the QR code with your digital device to go directly to the interactive Self-Test.

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Skilled Trades BC. (2021). *Book 2: Install fixtures and appliances, install sanitary and storm drainage systems.* Plumber apprenticeship program level 2 book 2 (Harmonized). Crown Publications: King's Printer for British Columbia.

Stephens, K. A., Graham, P., & Reid, D. (2002). *Stormwater planning*: A *guidebook for British Columba*. British Columbia Ministries of Community, Aboriginal and Women's Services and Water, Land and Air Protection. https://www2.gov.bc.ca/assets/gov/environment/waste-management/sewage/stormwater_planning_guidebook_for_bc.pdf

Trades Training BC. (2021). D-3: Install storm drainage systems. In: *Plumber Apprenticeship Program: Level 2*. Industry Training Authority, BC.

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- **Figure 3:** Arched infiltration chambers (https://commons.wikimedia.org/wiki/File:Parking_lot_stormwater_detention_system.jpg) by Arbitrarily0, via Wikimedia Commons, was used by Skilled Trades BC (2021) under a CC BY-SA 3.0 (https://creativecommons.org/licenses/by-sa/3.0/deed.en) license
- **Figure 4:** Engineered stormwater retention system (https://wiki.sustainabletechnologies.ca/wiki/

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- **Figure 5:** Green Roof (https://commons.wikimedia.org/wiki/File:British_Horse_Society_Head_Quarters_and_Green_Roof.jpg) by Sky Garden Ltd, via Wikimedia Commons was used by Skilled Trades BC (2021) under a CC BY-SA 4.0 (https://creativecommons.org/licenses/by-sa/4.0/deed.en) license.

Self-Test D-3.1 Storm Drainage Terminology

Complete Self-Test D-3.1 and check your answers.

1. What is the term given to wastewater with impurity levels that will not be harmful to health and may include HVAC condensate but does not include stormwater?
   a. Sewage
   b. Clearwater waste
   c. Effluent
   d. Potable water

2. What is the term given to a building drain that conducts stormwater and is connected at its upstream end to a leader, sump, or catch basin and at its downstream end to a building sewer or a designated stormwater disposal location?
   a. Sanitary building drain
   b. Storm branch
   c. Combined building drain
   d. Storm building drain

3. A roof drain, as defined by the NPC, is a drain installed to receive water collecting on the surface of a roof and to discharge the water into what location?
   a. Leader
   b. Storm building drain
   c. Combined building sewer
   d. Gutter

4. How far does a storm building drain continue outside the building wall before it can be considered a storm building sewer?
   a. 300 mm
   b. 1 m
   c. 3 m
   d. To the property line

5. What is the term given to a building drain that conducts stormwater and sewage?
   a. Sanitary building drain
   b. Storm branch
   c. Combined building drain
   d. Storm building drain

Answer Key: Self-Test D-3.1 (#chapter-answer-key-self-test-d-3-1) is on the next page.

Answer Key: Self-Test D-3.1

1. b. Clearwater waste
2. d. Storm building drain
3. a. Leader
4. b. 1 m
5. c. Combined building drain

Self-Test D-3.2 Functions of Pipes in Storm Drainage Systems

Complete Self-Test D-3.2 and check your answers.

1. What is the function of the dome installed over the drain opening in a flat roof drain?
   a. Acts as a warning device for a trip hazard for anyone on the roof
   b. Acts as a roof drain locating device when the roof is flooded due to a drain blockage
   c. Prevents debris from entering the drainage system from the roof
   d. Prevents winter ice and snow buildup on the drain inlet

2. A horizontal leader installed in conjunction with a siphonic roof drain is designed to flow at what capacity?
   a. 25% full
   b. 50% full
   c. 75% full
   d. 100% full

3. A flow-control roof drain system requires special building design considerations. Which of the following would be most important?
   a. Slope of the roof
   b. Structural design of the roof
   c. Height of the parapet wall
   d. Area of the roof

4. Other than acting as a stormwater collection device for a paved area, what other function does a catch basin serve for the storm drainage system?
   a. Traps debris that might otherwise enter the drainage system
   b. Discourages the entrance of rodents into the storm drainage system
   c. Allows all larger flows to be drained from the system without increasing the pipe size

5. What is the purpose of a CSO in regard to a municipal combined sewer system?
   a. Acts as a collection reservoir to detain untreated sewage until it can be properly treated at a sewage treatment plant
   b. Acts as a diverting device so the stormwater flow in the combined system is diverted around the sewage treatment plant without being treated
   c. Acts as an overflow mechanism so the combined drainage flow is allowed to flow to a discharge point in its raw form without treatment
   d. Acts as a metering chamber at the point of entry and allow only as much flow into the combined system as the sewage treatment plant can accommodate

Answer Key: Self-Test D-3.2 is on the next page.

Answer Key: Self-Test D-3.2

1. c. Prevents debris from entering the drainage system from the roof
2. d. 100% full
3. b. Structural design of the roof
4. a. Traps debris that might otherwise enter the drainage system
5. c. Acts as an overflow mechanism so the combined drainage flow is allowed to flow to a discharge point in its raw form without treatment

Self-Test 3.3 Storm Drainage Code Requirements

Complete Self-Test D-3.3 and check your answers.

1. Using Figure 2P-46, fill in Table 1 by identifying and sizing the storm drainage installation as per the NPC.

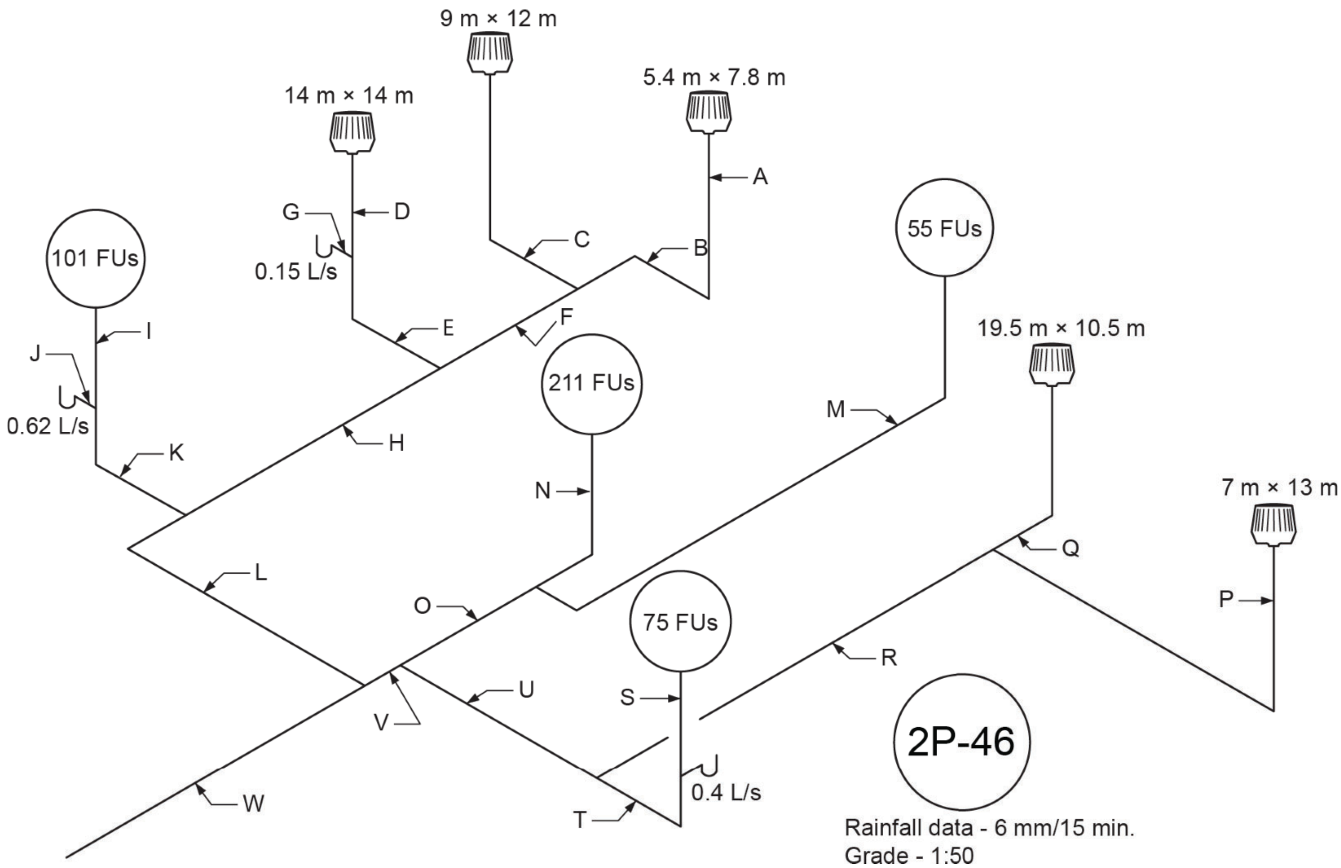

Figure 2P-46

Table 1

Letter	Name	Leader (m^2)	Load	Size
A				
B				
C				
D				
E				
F				
G				
H				
I				
J				
K				
L				
M				
N				
O				
P				
Q				
R				
S				
T				
U				
V				
W				

2. Using Figure 2P-47, fill in Table 2 by identifying and sizing the storm drainage installation as per the NPC.

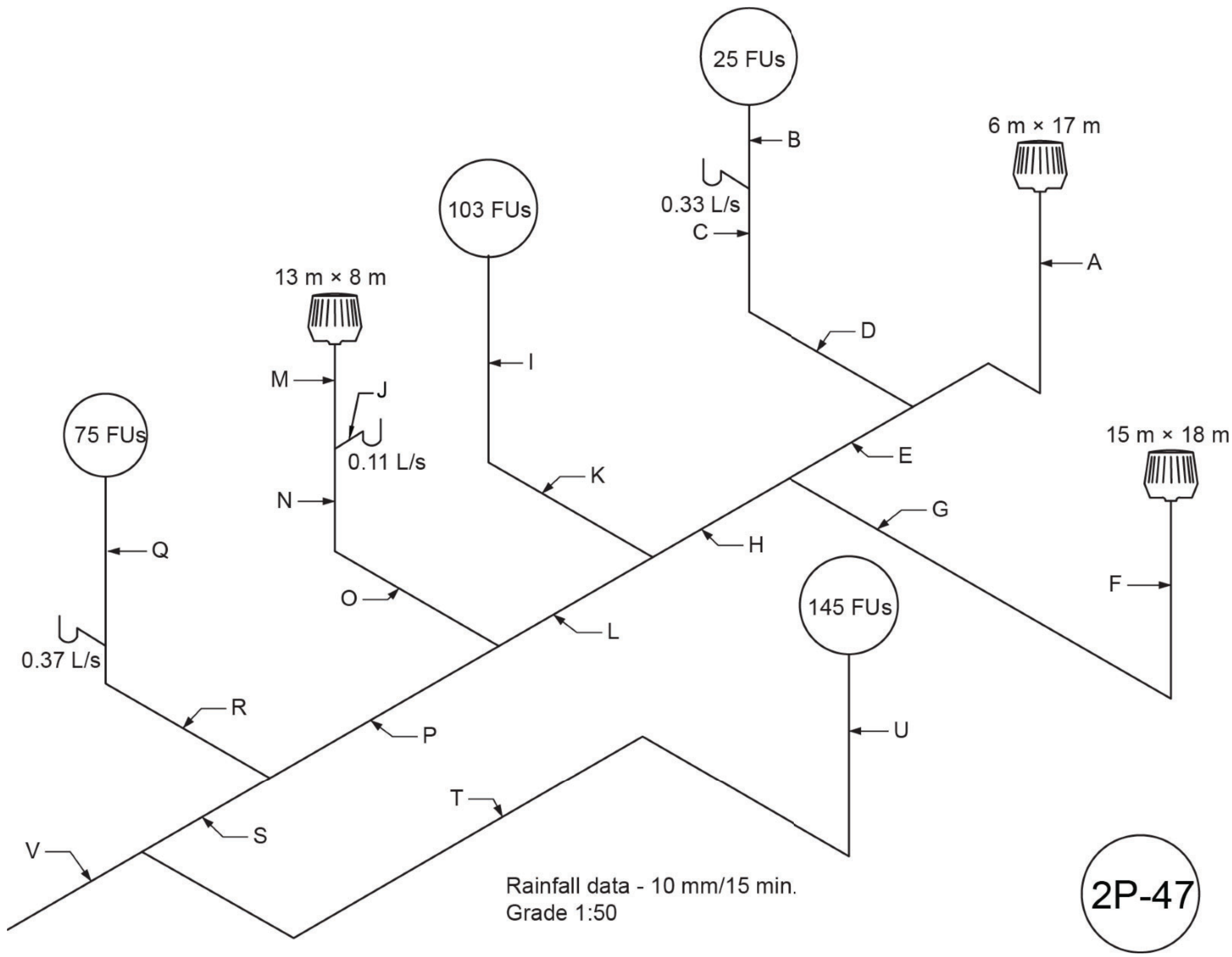
25 FUs
B
6 m × 17 m
103 FUs
0.33 L/s
C
A
13 m × 8 m
D
I
M
J
75 FUs
0.11 L/s
E
15 m × 18 m
N
K
G
Q
H
O
145 FUs
F
L
0.37 L/s
R
P
U
T
S
V
Rainfall data - 10 mm/15 min.
Grade 1:50
2P-47

Figure 2P-47

Table 2

Letter	Name	Leader (m^2)	Load	Size
A				
B				
C				
D				
E				
F				
G				
H				
I				
J				
K				
L				
M				
N				
O				
P				
Q				
R				
S				
T				
U				
V				

3. Using Figure 2P-48, fill in Table 3 by identifying and sizing the storm drainage installation as per the NPC.

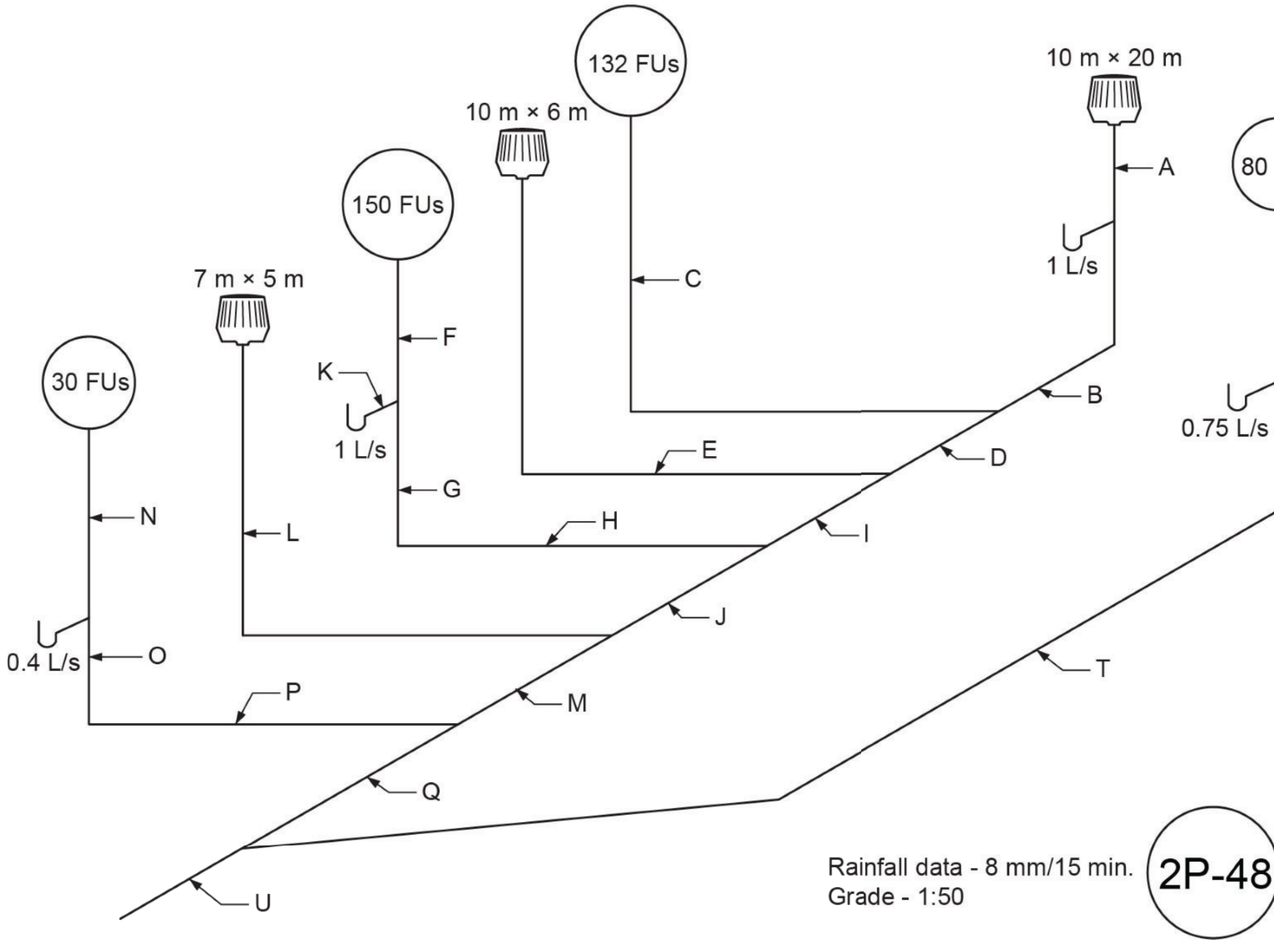
132 FUs
10 m × 20 m
10 m × 6 m
A
80 FUs
150 FUs
1 L/s
R
C
7 m × 5 m
F
30 FUs
K
B
1 L/s
0.75 L/s
E
D
S
G
N
L
H
I
J
0.4 L/s
O
T
P
M
Q
Rainfall data - 8 mm/15 min.
Grade - 1:50
2P-48
U

Figure 2P-48

Table 3

Letter	Name	Leader (m^2)	Load	Size
A				
B				
C				
D				
E				
F				
G				
H				
I				
J				
K				
L				
M				
N				
O				
P				
Q				
R				
S				
T				
U				

4. Using Figure 2P-49, fill in Table 4 by identifying and sizing the storm drainage installation as per the NPC.

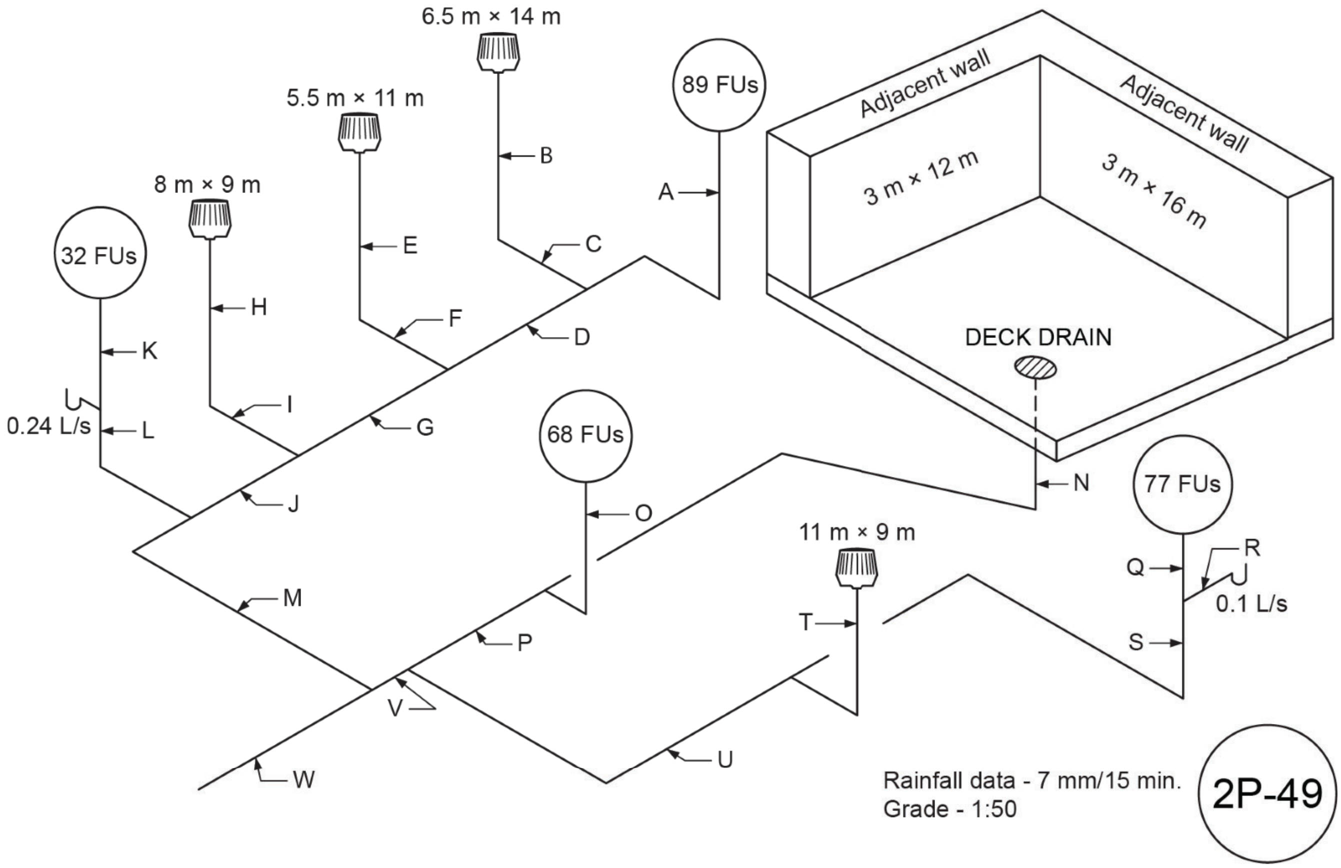
6.5 m × 14 m
89 FUs
Adjacent wall
Adjacent wall
5.5 m × 11 m
B
3 m × 12 m
3 m × 16 m
8 m × 9 m
A
E
C
32 FUs
H
F
D
DECK DRAIN
K
0.24 L/s
L
I
G
68 FUs
N
77 FUs
J
O
11 m × 9 m
R
Q
0.1 L/s
M
T
P
S
V
U
W
Rainfall data - 7 mm/15 min.
Grade - 1:50
2P-49

Figure 2P-49

Table 4

Letter	Name	Leader (m^2)	Load	Size
A				
B				
C				
D				
E				
F				
G				
H				
I				
J				
K				
L				
M				
N				
O				
P				
Q				
R				
S				
T				
U				
V				
W				

5. Using Figure 2P-50, fill in Table 5 by identifying and sizing the storm drainage installation as per the NPC.

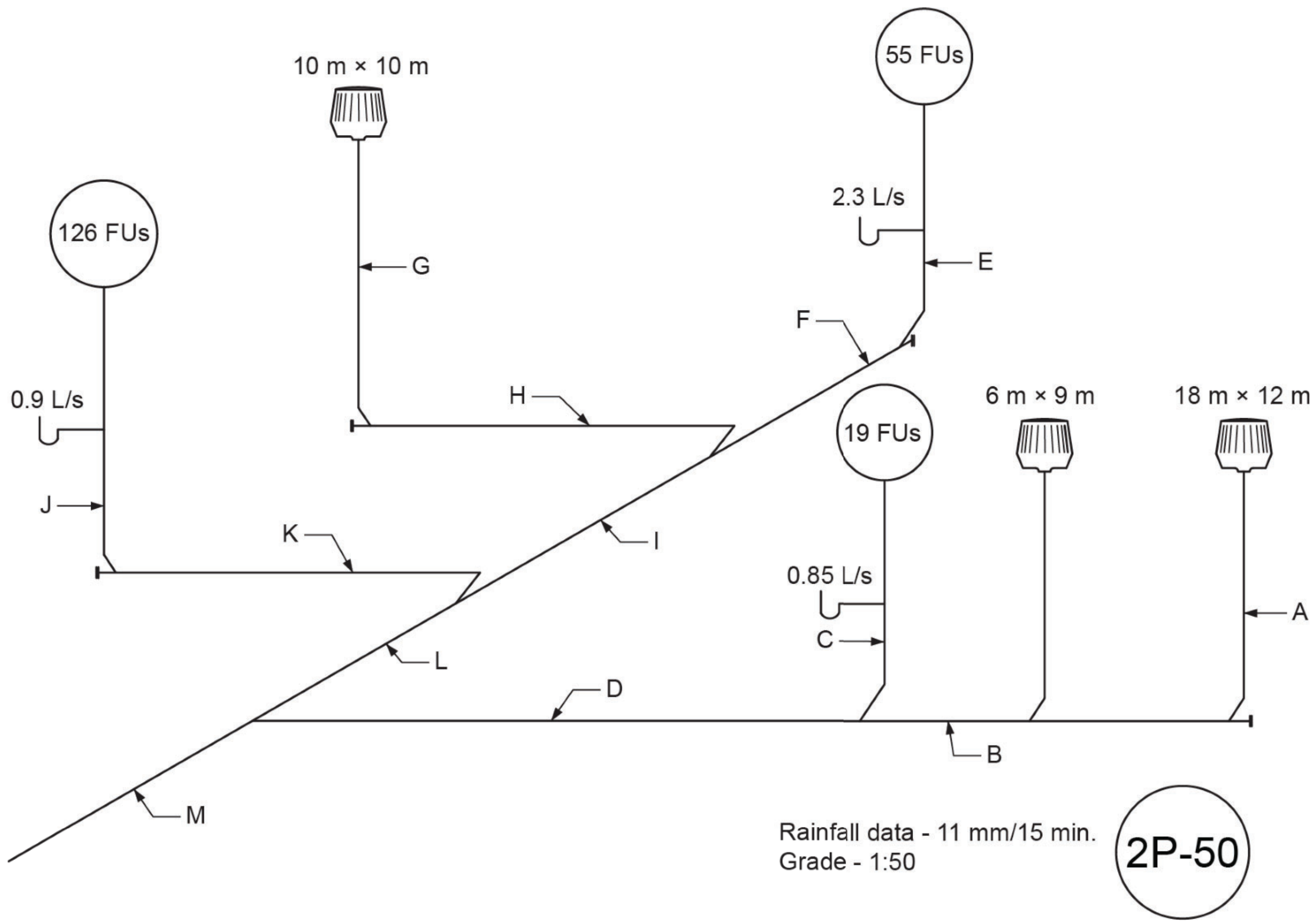

Figure 2P-50

Table 5

Letter	Name	Leader (m^2)	Load	Size
A				
B				
C				
D				
E				
F				
G				
H				
I				
J				
K				
L				
M				

6. Using Figure 2P-51, fill in Table 6 by identifying and sizing the storm drainage installation as per the NPC.

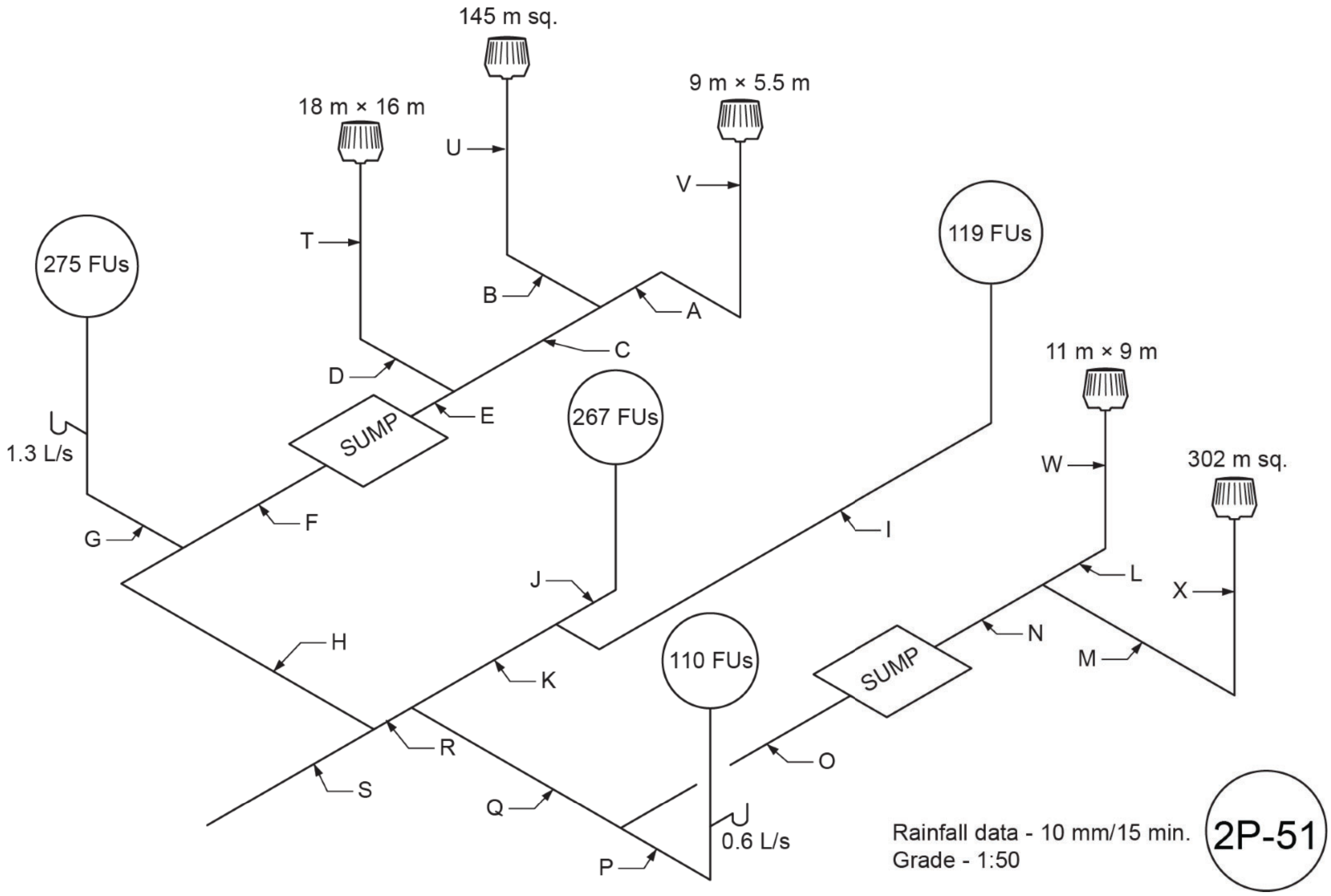
145 m sq.
9 m × 5.5 m
18 m × 16 m
U
V
T
275 FUs
119 FUs
B
A
C
D
11 m × 9 m
E
267 FUs
SUMP
1.3 L/s
W
302 m sq.
F
I
G
L
J
X
H
N
110 FUs
M
K
SUMP
R
O
S
Q
0.6 L/s
P
Rainfall data - 10 mm/15 min.
Grade - 1:50
2P-51

Figure 2P-51

Table 6

Letter	Name	Leader (m^2)	Load	Size
A				
B				
C				
D				
E				
F				
G				
H				
I				
J				
K				
L				
M				
N				
O				
P				
Q				
R				
S				
T				
U				
V				
W				
X				

7. Using Figure 2P-52, fill in Table 7 by identifying and sizing the storm drainage installation as per the NPC.

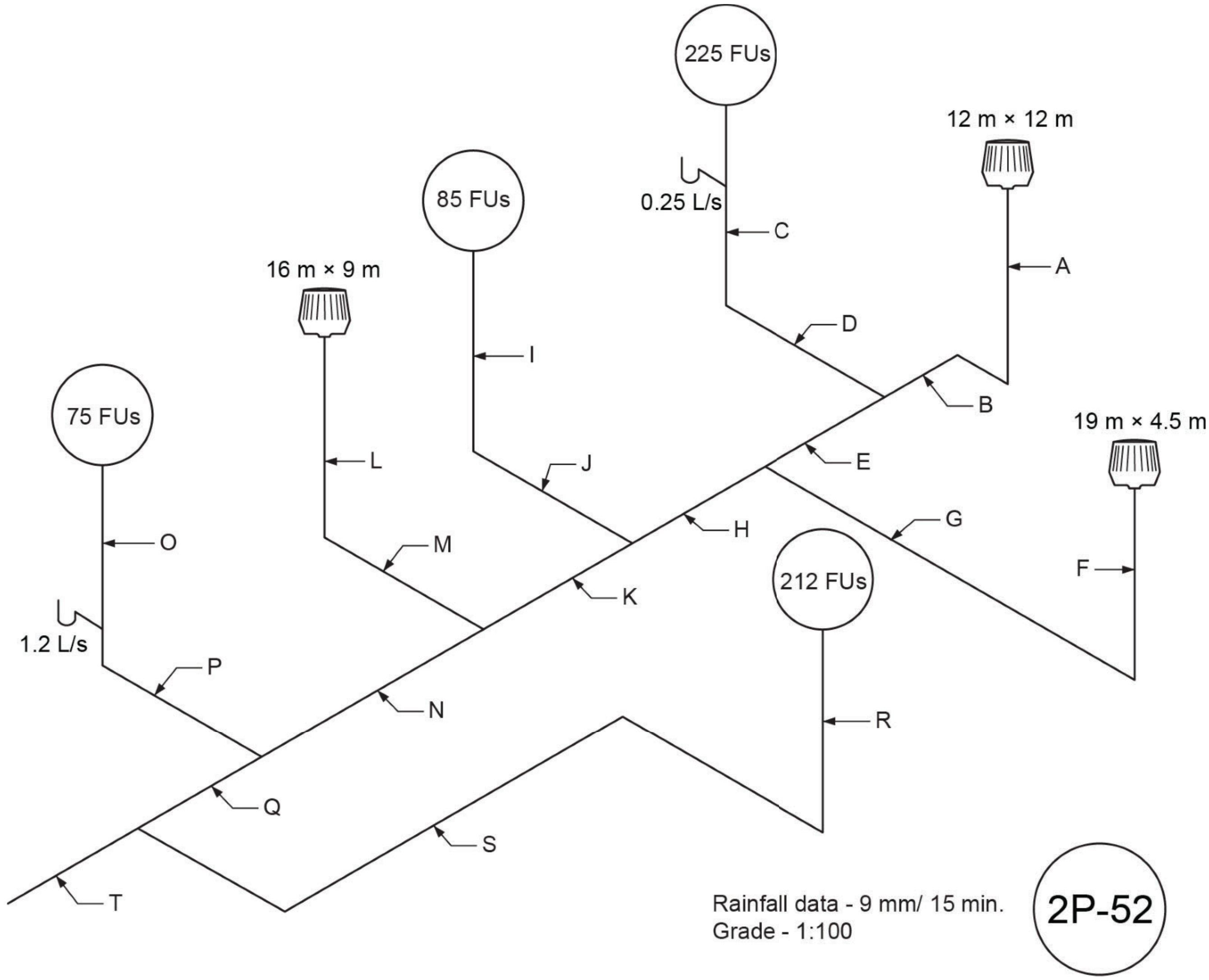
225 FUs
12 m × 12 m
0.25 L/s
C
A
85 FUs
16 m × 9 m
D
I
B
75 FUs
19 m × 4.5 m
L
J
E
O
M
H
G
K
212 FUs
F
1.2 L/s
P
N
R
Q
S
T
Rainfall data - 9 mm/ 15 min.
Grade - 1:100
2P-52

Figure 2P-52

Table 7

Letter	Name	Leader (m^2)	Load	Size
A				
B				
C				
D				
E				
F				
G				
H				
I				
J				
K				
L				
M				
N				
O				
P				
Q				
R				
S				
T				

8. What must be provided for when a roof drain is securely connected to a leader?
   a. Expansion
   b. Overflow
   c. Future loads
   d. Flow control

9. What feature must be installed when a drinking fountain is subject to backflow and directly connected to a storm drainage system?
   a. Air gap
   b. Air break
   c. Backwater valve
   d. Stop lift

10. If an indirectly connected 1.5 in. pipe forms an air break above a directly connected fixture to a storm drainage system, what is the minimum dimension of the air break?
   a. 1 in.
   b. 1.25 in.
   c. 1.5 in.

d. 2 in.

11. What is the maximum spacing of riser clamp supports for a vertical three-storey rainwater leader?
    a. 6.5 m
    b. 7.0 m
    c. 7.5 m
    d. 8.0 m

12. What is the maximum hanger spacing for horizontal cast-iron soil pipe?
    a. 1 m
    b. 2 m
    c. 3 m
    d. 4 m

13. A drainage pipe that conducts both sewage and storm water is prohibited to be installed in what plane?
    a. Vertical
    b. Horizontal

14. Which NPC table would be referred to when determining the maximum hydraulic load drained to a roof gutter?
    a. 2.4.10.6.C
    b. 2.4.10.9
    c. 2.4.10.10
    d. 2.4.10.11

15. Does the NPC allow drainage pans serving heating and cooling units to drain to a storm drainage system?
    a. Yes
    b. No

16. Does the NPC allow an overflow from a rainwater tank to be directly connected to a storm drainage system?
    a. Yes
    b. No

17. If a leader receives semi or continuous flow from an appliance, what is the minimum size of trap required if the flow rate is 2.2 L/s?
    a. 2 in.
    b. 3 in.
    c. 4 in.
    d. 6 in.

18. What is the minimum size of circular leader that receives a load of 30,000 L?

a. 2 in.
b. 3 in.
c. 4 in.
d. 6 in.

19. Does the NPC allow a food display compartment to be directly connected to a storm drainage system?
    a. Yes
    b. No

20. Does the NPC require a vent to protect a 2 in. floor drain connected to a storm drainage system?
    a. Yes
    b. No

21. A 16 m by 18 m flat roof is served by a roof drain with three adjacent walls. The dimensions of the walls are: 16 m by 3 m, 18 m by 1 m, and 18 m by 1.5 m. What would be the load on the roof drain if the rainfall intensity was 7 mm/15 min?
    a. 2,016 L
    b. 2,184 L
    c. 2,205 L
    d. 2,352 L

22. The RWL serving the roof drain in the previous question has an HVAC unit draining into it with a semi-continuous flow of 0.4 L/s. What load is to be considered at the base of the RWL?
    a. 2,360 L
    b. 2,544 L
    c. 3,360 L
    d. 4,376 L

23. A combined building drain receives discharges of 477 FU, 1.3 L/s of continuous flow, and 3,200 L/15 min of storm drainage. What would be the load to consider when sizing the combined building drain?
    a. 2,360.5 L
    b. 6,730.8 L
    c. 7,810.4 L
    d. 8,710.7 L

24. An outdoor restaurant patio is served by a storm drain that eventually connects to a combined building sewer. Does the storm drain require a trap?
    a. Yes
    b. No
    c. Not if the patio is on the roof
    d. Not if the storm drain is not subject to backflow

25. You are installing a rainwater leader through a building. You have to offset the leader horizontally to accommodate a change in wall location. The offset you install measures 7.2 m. According to NPC requirements, what must the leader be sized as?
    a. Storm branch
    b. Leader but one size larger than it was prior to the offset
    c. Sanitary building drain
    d. Storm building drain

26. You are asked to install flow-control roof drains on a flat roof that measures 90 m by 60 m. What is the minimum number of drains required for this installation?
    a. 2
    b. 4
    c. 6
    d. 8

27. Referring to the above-mentioned installation, what would be the minimum number of overflow scuppers installed in conjunction with flow-control roof drains?
    a. 4
    b. 6
    c. 8
    d. 10

Answer Key: Self-Test D-3.3 (#chapter-answer-key-self-test-d-3-3) is on the next page.

Answer Key: Self-Test D-3.3

1. Figure 2P-46

Table 1 Answers

Letter	Name	Leader (m^2)	Load	Size
A	RWL	42.12	252.72 L	2 in.
B	Storm building drain	N/A	252.72 L	3 in.
C	Storm building drain	N/A	648 L	3 in.
D	RWL	196	1,176 L	2 in.
E	Storm building drain	N/A	1,311 L	3 in.
F	Storm building drain	N/A	900.72 L	3 in.
G	Trap arm fixture drain	N/A	135 L	2 in.
H	Storm building drain	N/A	2211.72 L	3 in.
I	Stack	N/A	101 FU	3 in.
J	Trap arm fixture drain	N/A	19.65 FU	3 in.
K	Sanitary building drain	N/A	120.65 FU	4 in.
L	Combined building drain	N/A	5,129.72 L	4 in.
M	Sanitary building drain	N/A	55 FU	4 in.
N	Stack	N/A	211 FU	4 in.
O	Sanitary building drain	N/A	266 FU	5 in.
P	RWL	91	546 L	2 in.
Q	Storm building drain	N/A	1,228.5 L	3 in.
R	Storm building drain	N/A	1,774.5 L	3 in.
S	Stack	N/A	75 FU	3 in.
T	Sanitary building drain	N/A	87.68 FU	4 in.
U	Combined building drain	N/A	4,494.5 L	4 in.
V	Combined building drain	N/A	5,237.6 L	5 in.
W	Combined building drain	N/A	8,926.42	5 in.

2. Figure 2P-47

Table 2 Answers

Letter	Name	Leader (m^2)	Load	Size
A	RWL	102	1,020 L	2 in.
B	Stack	N/A	25 FU	3 in.
C	Stack	N/A	35.46 FU	3 in.
D	Sanitary building drain	N/A	35.46 FU	4 in.
E	Combined building drain	N/A	3,677 L	4 in.
F	RWL	270	2,700 L	2.5 in.
G	Storm building drain	N/A	2,700 L	3 in.
H	Combined building drain	N/A	6,377 L	5 in.
I	Stack	N/A	103 FU	4 in.
J	Trap arm fixture drain	N/A	99 L	2 in.
K	Sanitary building drain	N/A	103 FU	4 in.
L	Combined building drain	N/A	6,377 L	5 in.
M	RWL	104	1,040 L	2 in.
N	RWL	104	1,139 L	2 in.
O	Storm building drain	N/A	1,139 L	3 in.
P	Combined building drain	N/A	7,516 L	5 in.
Q	Stack	N/A	75 FU	3 in.
R	Sanitary building drain	N/A	86.73 FU	4 in.
S	Combined building drain	N/A	7,849 L	5 in.
T	Sanitary building drain	N/A	145 FU	4 in.
U	Stack	N/A	145 FU	4 in.
V	Combined building drain	N/A	8,655.8 L	5 in.

3. Figure 2P-48

Table 3 Answers

Letter	Name	Leader (m^2)	Load	Size
A	RWL	200	1,600 L	2 in.
B	Storm building drain	N/A	2,500 L	4 in.
C	Stack	N/A	132 FU	4 in.
D	Combined building drain	N/A	4,680 L	4 in.
E	Storm building drain	N/A	480 L	3 in.
F	Stack	N/A	150 FU	4 in.
G	Stack	N/A	181.7 FU	4 in.
H	Sanitary building drain	N/A	181.7 FU	4 in.
I	Combined building drain	N/A	5,340 L	4 in.
J	Combined building drain	N/A	6,446.2 L	5 in.
K	Trap arm fixture drain	N/A	31.7 FU	4 in.
L	RWL	35	280 L	2 in.
M	Combined building drain	N/A	6,726.2 L	5 in.
N	Stack	N/A	30 FU	3 in.
O	Stack	N/A	42.68 FU	3 in.
P	Sanitary building drain	N/A	42.68 FU	4 in.
Q	Combined building drain	N/A	7,359.2 L	5 in.
R	Stack	N/A	80 FU	3 in.
S	Stack	N/A	103.78 FU	4 in.
T	Sanitary building drain	N/A	103.78 FU	4 in.
U	Combined building drain	N/A	8,762.2 L	5 in.

4. Figure 2P-49

Table 4 Answers

Letter	Name	Leader (m^2)	Load	Size
A	Stack	N/A	89 FU	3 in.
B	RWL	91	637 L	2 in.
C	Storm building drain	N/A	637 L	3 in.
D	Combined building drain	N/A	2,997 L	4 in.
E	RWL	60.5	423.5 L	2 in.
F	Storm building drain	N/A	423.5 L	3 in.
G	Combined building drain	N/A	3,420.5 L	4 in.
H	RWL	72	504 L	2 in.
I	Storm building drain	N/A	504 L	3 in.
J	Combined building drain	N/A	3,924.5 L	4 in.
K	Stack	N/A	32 FU	3 in.
L	Stack	N/A	39.61 FU	3 in.
M	Combined building drain	N/A	4,140.5 L	4 in.
N	RWL	216	1,512 L	2 in.
O	Stack	N/A	68 FU	3 in.
P	Combined building drain	N/A	3,872 L	4 in.
Q	Stack	N/A	77 FU	3 in.
R	Trap arm fixture drain	N/A	3.17 FU	2 in.
S	Stack	N/A	80.17 FU	3 in.
T	RWL	99	693 L	2 in.
U	Combined building drain	N/A	3,143 L	4 in.
V	Combined building drain	N/A	4,655 L	4 in.
W	Combined building drain	N/A	6,496.1 L	5 in.

5. Figure 2P-50

Table 5 Answers

Letter	Name	Leader (m^2)	Load	Size
A	RWL	N/A	2,376 L	2.5 in.
B	Storm building drain	N/A	2,970 L	4 in.
C	Stack	N/A	45.95 FU	4 in. — 26.945 FU from one floor
D	Combined building drain	N/A	6,095 L	5 in.
E	Stack	N/A	127.91 FU	4 in.
F	Sanitary building drain	N/A	127.91 FU	4 in.
G	RWL	100	1,100 L	2 in.
H	Storm building drain	N/A	1,100 L	3 in.
I	Combined building drain	N/A	5,530 L	4 in.
J	Stack	N/A	154.53 FU	4 in.
K	Sanitary building drain	N/A	154.53 FU	4 in.
L	Combined building drain	N/A	6,340 L	5 in.
M	Combined building drain	N/A	10,075 L	5 in.

6. Figure 2P-51

Table 6 Answers

Letter	Name	Leader (m^2)	Load	Size
A	Storm building drain	N/A	495 L	3 in.
B	Storm building drain	N/A	1,450 L	3 in.
C	Storm building drain	N/A	1,945 L	3 in.
D	Storm building drain	N/A	2,880 L	4 in.
E	Storm building drain	N/A	4,825 L	4 in.
F	Storm building drain	N/A	4,825 L	4 in.
G	Sanitary building drain	N/A	216.21 FU	5 in.
H	Combined building drain	N/A	8,497.5 L	5 in.
I	Sanitary building drain	N/A	119 FU	4 in.
J	Sanitary building drain	N/A	267 FU	5 in.
K	Sanitary building drain	N/A	386 FU	5 in.
L	Storm building drain	N/A	990 L	3 in.
M	Storm building drain	N/A	3,020 L	4 in.
N	Storm building drain	N/A	4,010 L	4 in.
O	Storm building drain	N/A	4,010 L	4 in.
P	Sanitary building drain	N/A	129.02	4 in.
Q	Combined building drain	N/A	6,910 L	5 in.
R	Combined building drain	N/A	9,063.6 L	5 in.
S	Combined building drain	N/A	17,561.1 L	6 in.
T	RWL	288	2,280 L	2.5 in.
U	RWL	145	1,450 L	2 in.
V	RWL	49.5	495 L	2 in.
W	RWL	99	990 L	2 in.
X	RWL	302	3,020 L	2.5 in.

7. Drawing 2P-52

Table 7 Answers

Letter	Name	Leader (m^2)	Load	Size
A	RWL	144	1,296 L	2 in.
B	Storm building drain	N/A	1,296 L	4 in
C	Stack	N/A	232.93 FU	4 in.
D	Sanitary building drain	N/A	232.93 FU	5 in.
E	Combined building drain	N/A	3,881 L	5 in.
F	RWL	85.5	769.5 L	2 in.
G	Storm building drain	N/A	769.5 L	4 in.
H	Combined building drain	N/A	4,650 L	5 in.
I	Stack	N/A	85 FU	3 in.
J	Sanitary building drain	N/A	85 FU	4 in.
K	Combined building drain	N/A	5,111.5 L	5 in.
L	RWL	144	1,296 L	2 in.
M	Storm building drain	N/A	1,296 L	4 in.
N	Combined building drain	N/A	6,407.5 L	5 in.
O	Stack	N/A	75 FU	3 in.
P	Sanitary building drain	N/A	113.04 FU	4 in.
Q	Combined building drain	N/A	8,170 L	6 in.
R	Stack	N/A	212 FU	4 in.
S	Sanitary building drain	N/A	212 FU	5 in.
T	Combined building drain	N/A	10,099.2 L	6 in.

8. a. Expansion
9. c. Backwater valve
10. c. 1.5 in.
11. c. 7.5 m
12. c. 3 m
13. a. Vertical
14. c. 2.4.10.10
15. a. Yes
16. b. No
17. c. 4 in.
18. d. 6 in.
19. b. No
20. b. No
21. b. 2,184 L

22. b. 2,544 L
23. d. 8,710.7 L
24. a. Yes
25. d. Storm building drain
26. c. 6
27. d. 10

Self-Test D-3.4 Planning the Storm System

Complete Self-Test D-3.4 and check your answers.

1. What is the recommended minimum number of roof drains for any size individual roof?
    a. 1
    b. 2
    c. 3
    d. 4

2. Which of the following advantages is not associated with interior rainwater leaders?
    a. Lower cost
    b. Appearance
    c. Convenience
    d. Freeze protection

3. If the decision is made to install a leader at a building column location, what professional should be consulted prior to the installation?
    a. Mechanical engineer
    b. Electrical engineer
    c. Structural engineer
    d. Architect

4. What type of fitting is installed in a storm drainage piping system to accommodate pipe movement without affecting the placement of a roof drain?
    a. MJ clamp
    b. Expansion joint
    c. Fernco coupling
    d. Slip coupling

5. What part of the building envelope would be damaged if a proper pipe anchoring system were not in place when installing a rainwater leader to a roof drain?
    a. Piping material
    b. Roof truss system
    c. Expansion joint
    d. Waterproof membrane

Answer Key: Self-Test D-3.4 (#chapter-answer-key-self-test-d-3-4) is on the next page.

Answer Key: Self-Test D-3.4

1. b. 2
2. a. Lower cost
3. c. Structural engineer
4. b. Expansion joint
5. d. Waterproof membrane

Self-Test D-3.5 Installing Storm Drainage Systems

Complete Self-Test D-3.5 and check your answers.

1. What is the smallest size of storm drainage piping that is allowed to be installed at a slope of 1:100?
    a. 2 in.
    b. 3 in.
    c. 4 in.
    d. 5 in.

2. When installing a roof drain body on a flat roof, which device holds the drain body in place?
    a. Sump receiver
    b. Underdeck clamp
    c. Clamping collar
    d. Drain dome

3. When installing a roof drain body on a flat roof, which device clamps the waterproof membrane to the drain body?
    a. Sump receiver
    b. Underdeck clamp
    c. Clamping collar
    d. Drain dome

4. When installing a roof drain body on a flat roof, which device is the roof dome attached to?
    a. Sump receiver
    b. Underdeck clamp
    c. Clamping collar
    d. Drain body

Answer Key: Self-Test D-3.5 (#chapter-answer-key-self-test-d-3-5) is on the next page.

Answer Key: Self-Test D-3.5

1. c. 4 in.
2. b. Underdeck clamp
3. c. Clamping collar
4. c. Clamping collar

Self-Test D-3.6 Sumps and Catch Basins

Complete Self-Test D-3.6 and check your answers.

1. Complete the following statement: “A catch basin is a form of ______.”
   a. Trap
   b. Fixture
   c. Interceptor
   d. Appurtenance

2. What is/are commonly used to bring the grate of a round concrete catch basin up to the desired final elevation?
   a. Extension rings
   b. Elevation fittings
   c. More grates
   d. Vertical pipe

3. What is commonly cast into concrete catch basins to be used as lifting eyes?
   a. Bolts
   b. Nuts
   c. Washers
   d. Wire rope

4. What is installed inside a catch basin that prevents floating debris from being carried into the outlet piping?
   a. Backwater valve
   b. Downturned 90
   c. Check valve
   d. Gate valve

5. What is often cast into a catch basin’s grate to alert the public of environmental concerns downstream?
   a. Red flag
   b. Fish icon
   c. Skull and crossbones icon
   d. “Danger do not operate” warning

6. What might be installed in front of a garage that is below the elevation of the adjoining street?
   a. Trough drain
   b. Sewage sump
   c. French drain
   d. Subsoil drain

7. Which one of the following statements is correct?
    a. A catch basin has no piping outlet.
    b. A sump needs to be pumped out.
    c. A sewage sump has an open top.
    d. A catch basin needs a vent.

8. Where a sump does not operate automatically, its capacity shall be sufficient to hold at least how many hours of liquid accumulation.
    a. 1
    b. 6
    c. 12
    d. 24

9. What is the name of a piping system that is too low to drain by gravity to a building drain?
    a. Sub-drainage system
    b. Sub-soil drainage system
    c. Continuous waste system
    d. Combined building drainage system

10. What is commonly attached to the cord of a float switch in a sump to allow it to operate properly?
    a. Sensor
    b. Circuit breaker
    c. Lead weight
    d. Steel coupling

11. What happens if float switch #3 in a sump containing two pumps becomes inverted?
    a. Nothing
    b. Both pumps will shut off.
    c. Both pumps will come on.
    d. An alarm will sound.

12. What is sometimes used instead of a common support bar and lead weights to ensure that the float switches in a sump will operate properly?
    a. Individual support bars
    b. Vertical pipe or pole
    c. Individual alarm panels
    d. Submerged pressure switch

13. What is the result of a float switch that is turned upside down vertically?
    a. Reverses polarity
    b. Nothing happens.

c. “Breaks”
d. “Makes”

14. Which one of the following choices is not referenced as a component of a rail and yoke system for a sump?
    a. Yoke
    b. Base fitting
    c. Ridged electrical conduit
    d. Hinged connection with rubber seals

15. A sump with two pumps would be what type of system?
    a. Duplex
    b. Simplex
    c. Cineplex
    d. Complex

16. How many float switches are found in a residential packaged sump system?
    a. 1
    b. 2
    c. 3
    d. 4

17. How many openings are required in the lid of a packaged sump?
    a. 1
    b. 2
    c. 3
    d. 4

18. What are toilets that have a self-contained sump with a pump known as?
    a. Washdown
    b. Washout
    c. Siphon jet
    d. Macerating

19. What is the main installation consideration for installing bathtubs and showers that drain into an above-grade sump?
    a. Must be white
    b. Must be made of plastic
    c. Must be elevated on platforms
    d. Must not be used in any basement

20. What are the voltage and current values for the electrical circuit that powers a residential sump?

a. 120 volt, single-phase direct current
b. 208 volt, three-phase alternating current
c. 120 volt, single-phase alternating current
d. 240 volt, three-phase alternating current

Answer Key: Self-Test D-3.6 (#chapter-answer-key-self-test-d-3-6) is on the next page.

Answer Key: Self-Test D-3.6

1. c. Interceptor
2. a. Extension rings
3. d. Wire rope
4. b. Downturned 90
5. b. Fish icon
6. a. Trough drain
7. b. A sump needs to be pumped out.
8. d. 24
9. a. Subdrainage system
10. c. Lead weight
11. c. Both pumps will come on.
12. b. Vertical pipe or pole
13. d. "Makes."
14. c. Ridged electrical conduit
15. a. Duplex
16. a. 1
17. c. 3
18. d. Macerating
19. c. Must be elevated on platforms.
20. c. 120-volt, single-phase, alternating current

Self-Test D-3.7 Sub-soil Drainage Systems

Complete Self-Test D-3.7 and check your answers.

1. What is the term given to the scientific study of the movement, distribution, and management of water on Earth?
    a. Hydrology
    b. Hydronomy
    c. Hydroscopy
    d. Hydroelectricity

2. Which one of the following is not a true statement when moisture is removed from the ground around footings by installing subsoil drains?
    a. Ponding is reduced.
    b. The water table is lowered.
    c. Soils become waterlogged.
    d. Soil strength is stabilized or increased.

3. What was often the shape or profile of the outside of short lengths of drain tile?
    a. Triangular
    b. Octagonal
    c. Hexagonal
    d. Pentagonal

4. How much space was there intended to be between lengths of vitrified tile drainage pipe?
    a. $\frac{1}{16}$ in. to $\frac{1}{8}$ in.
    b. $\frac{1}{8}$ in. to $\frac{1}{4}$ in.
    c. $\frac{1}{4}$ in. to $\frac{1}{2}$ in.
    d. $\frac{3}{4}$ in. to 1 in.

5. How many degrees apart are the perforations on common PVC perforated pipe?
    a. 45°
    b. 60°
    c. 90°
    d. 120°

6. According to the BC Building Code, where should the top of the pipe used for footing drains be located?
    a. Below the bottom of the floor slab or ground cover of the crawl space
    b. Above the bottom of the floor slab or ground cover of the crawl space

c. Below the bottom of the footing
d. Above the bottom of the footing

7. What type of layer protects the drain rock and perforated pipe from becoming plugged with fines from the soil?
    a. Plastic film
    b. Newspaper
    c. Linen
    d. Geotextile fabric

8. What is the term for an excavated hole in the ground that is filled with drain rock and used as a terminal for storm or subsurface water?
    a. Well
    b. Dry well
    c. Wet well
    d. Water well

9. What is the term that is sometimes used to describe a trench; perforated pipe; clean, washed rock; geotextile fabric; and backfill intended for subsurface drainage?
    a. Ditch drain
    b. French drain
    c. Canadian drain
    d. Below-surface drain

10. What is the name given to a drain that might be installed at the foot of a rock face and that is intended to intercept and channel away water that would pond at the base of the slope?
    a. Rockface drain
    b. Channel drain
    c. Curtain drain
    d. Slope drain

11. What is the term given to the process of creating horizontal holes underground that water can flow through to get to a trench drain?
    a. Moling
    b. Tunnelling
    c. Chambering
    d. Crosshatching

12. What is the average depth of the pipe in a trench drain used as the main drain associated with the question above?
    a. 300 mm (1 ft)
    b. 600 mm (2 ft)
    c. 1,200 mm (4 ft)
    d. 1,800 mm (6 ft)

Answer Key: Self-Test D-3.7 (#chapter-answer-key-self-test-d-3-7) is on the next page.

Answer Key: Self-Test D-3.7

1. a. Hydrology
2. c. Soils become waterlogged
3. b. Octagonal
4. c. $\frac{1}{4}$ in. to $\frac{1}{2}$ in.
5. d. 120
6. a. Below the bottom of the floor slab or groundcover of the crawl space
7. d. Geotextile fabric
8. b. Dry well
9. b. French drain
10. c. Curtain drain
11. a. Moling
12. c. 1,200 mm (4 ft)

Self-Test D-3.8 Stormwater Site-Retention Systems

Complete Self-Test D-3.8 and check your answers.

1. What is the term given to the natural flow of precipitation over land surfaces?
   a. Water table
   b. Run on
   c. Runoff
   d. Water cycle

2. What is the term given to the practice of holding runoff water on a site and releasing it slowly back into the water table?
   a. Stormwater detention
   b. Stormwater retention
   c. Drainage ditching
   d. Stormwater saving

3. What type of landscaping will promote stormwater entering the water table?
   a. Low-water
   b. Hard
   c. Soft
   d. Absorbent

4. What type of roof would be used in a source control stormwater practice?
   a. Blue
   b. Green
   c. Hard
   d. Soft

5. What is required when an onsite stormwater reuse system is constructed?
   a. Storage tank
   b. Expansion tank
   c. Storm valve
   d. Circuit vent

Answer Key: Self-Test D-3.8 (#chapter-answer-key-d-3-8-self-test) is on the next page.

Answer Key: D-3.8 Self-Test

1. c. Runoff
2. b. Stormwater retention
3. d. Absorbent
4. b. Green
5. a. Storage tank

Plumbing Apprenticeship & Trade Resources in BC

A successful career in plumbing requires a strong foundation of skills, knowledge, and workplace safety awareness. Below are key resources to support plumbing apprentices in BC, including educational pathways, trade certifications, workplace safety guidelines, and mental health and wellness support.

Plumbing Apprenticeship & Certification Resources

- **SkilledTradesBC – Plumbing Apprenticeship (https://skilledtradesbc.ca/plumber)** — Overview of plumbing training, certification requirements, and apprenticeship pathways in British Columbia.
- **Red Seal Program – Plumber (https://www.red-seal.ca/eng/trades/plumbers/overview.shtml)** — National certification program with exam prep guides and trade mobility information.
- **BC Building Codes & Standards (https://www.bccodes.ca/)** — Official building and plumbing codes for British Columbia.

Workplace Safety & Regulations

- **WorkSafeBC (https://www.worksafebc.com/en)** — Essential safety resources for plumbers, including:
    - Health & Safety – WorkSafeBC (https://www.worksafebc.com/en/health-safety)
    - Report Unsafe Working Conditions (https://www.worksafebc.com/en/contact-us/departments-and-services/health-safety-prevention)
    - Report a Workplace Injury or Disease (https://www.worksafebc.com/en/claims/report-workplace-injury-illness)
    - Submit a Notice of Project Form (https://www.worksafebc.com/en/for-employers/just-for-you/submit-notice-project)
    - Get Health and Safety Resources (Videos, Posters, Publications, and More) (https://www.worksafebc.com/en/resources-health-safety)
    - Search the OHS Regulations (and Related Materials) (https://www.worksafebc.com/en/law-policy/occupational-health-safety/searchable-ohs-regulation)
    - Conduct an Incident Investigation (https://www.worksafebc.com/en/health-safety/create-manage/incident-investigations/conducting-employer-investigation)
- **CCOHS: OHS Answers Fact Sheets – Plumber (https://www.ccohs.ca/oshanswers/occup_workplace/plumber.html)** — Safety guidelines and best practices for plumbers in various work environments.

Financial Supports

- **Financial Support (SkilledTradesBC)** (https://skilledtradesbc.ca/financial-support) — Information about grants, tax credits, Canada apprentice loans, employment insurance, and the Indigenous Skills and Employment Training

(ISET) program.
- **StudentAidBC (https://studentaidbc.ca/)** — Complete post-secondary education through student loans, grants, and scholarships. There is also programs that help with loan repayment.
- **WorkBC (Government of BC)** (https://www.workbc.ca/find-loans-and-grants/students-and-adult-learners/services-apprentices-and-employers) — Services for apprentices and employers.

Mental Health & Wellness Support

- **HealthLink BC – Mental Health and Substance Use** (https://www.healthlinkbc.ca/mental-health-and-substance-use) — HealthLink BC resources for mental health and wellness support.
- **Here2Talk** (https://here2talk.ca/) — Free and confidential counseling services available to all post-secondary students registered at a BC school.
- **Help Starts Here** (https://helpstartshere.gov.bc.ca/) — A database with over 2,500 listings of services related to mental health and substance use supports.
- **Hope for Wellness Helpline** (https://www.hopeforwellness.ca/) — 24/7 online chat and phone line with experienced and culturally competent counselors available to all Indigenous people in Canada.
    - First Nations Health Authority Mental Health Supports Info Sheet [PDF] (https://www.fnha.ca/Documents/FNHA-mental-health-and-wellness-supports-for-indigenous-people.pdf) by First Nations health Authority — List of culturally safe services for Indigenous people.
- **HeretoHelp – BC** (https://www.heretohelp.bc.ca/) — Mental health resources, including videos, articles, and support services in BC.
- **BC Construction Industry Rehabilitation Plan** (https://www.constructionrehabplan.com/) — Mental health and substance use services for CLRA and BCBT members and their families.
- **Virtual Mental Health Supports (Government of BC)** (https://www2.gov.bc.ca/gov/content/health/managing-your-health/mental-health-substance-use/virtual-mental-health-supports) — Virtual services are available for British Columbians who are experiencing anxiety, depression, or other mental health challenges.

Crisis Support

- **Interior Crisis Line Network** — Call 1-888-353-2273 (tel:+1-888-353-2273) for 24/7 emotional support, crisis intervention, and community resource information.
- **Talk Suicide Chat Service** (https://talksuicide.ca/) — An alternative if calling is difficult; available for crisis intervention.
- **310Mental Health Support** — Call 250-310-6789 (tel:+1-250-310-6789) for emotional support, information, and resources specific to mental health.
- **1-800-SUICIDE** — Call 1-800-784-2433 (tel:+1-800-784-2433) if you are experiencing feelings of distress or despair, including thoughts of suicide.
- **Opioid Treatment Access Line** — Call 1-833-804-8111 (tel:+1-833-804-8111) between 9 am and 4 pm to connect with a doctor, nurse, or healthcare worker who can prescribe opioid treatment medication that same day.
- **KUU-US Crisis Response Service** — Call 1-800-588-8717 (tel:+1-800-588-8717) for culturally-aware crisis support for Indigenous peoples in BC.
- **Alcohol and Drug Information and Referral Service** — Call 1-800-663-1441 (tel:+1-800-663-1441) to find resources and support.

Emergency Services — For life-threatening situations, call 911 or visit your nearest emergency department.

Version History

This page provides a record of changes made to this learning resource, Plumbing Apprenticeship Level 2, Block D (https://d-drainagesystems-bcplumbingapprl2.pressbooks.tru.ca/). Each update increases the version number by 0.1. The most recent version is reflected in the exported files for this resource.

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Version	Date	Change	Details
1.0	September, 2025	Plumbing Apprenticeship Level 2 Block D learning resource from STBC content converted to open and freely accessible digital platform and published at TRU.	Published in September 2025; and released October 2025 by TRU Open Press.
1.01	November 24, 2025	Updates to Figures in D-1.10 and Figures and Answer key for Self-test D-1.8.	Figure 20 (D-1.10) – measurements removed; Figures 2P-28 and 2P-35 (Self-test D-1.8) – measurement and labels changed, Table 8 Answers key adjusted for H and I (Self-test D-1.8)