



Abdelhafid Boussouf University Center - Mila

2024-2025 Semester 1

Water distribution and collection:

PART II: Sanitation

– Lesson 4 –

Chapter 04 : *Alternative techniques in stormwater drainage, principle and sizing.*



Teaching staff

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Students concerned

Institute	Department	Year	Speciality
Science and Technology	GC and hydraulic	2nd year master	Urban hydraulics

Course objective

At the end of this chapter, the student should be able to:

- Understand the general principles of alternative stormwater drainage techniques and their role in sustainable rainwater management.
- Identify the different types of devices (swales, drainage trenches, basins infiltration, green roofs, permeable pavements, etc.).
- Explain the associated hydrological mechanisms: infiltration, retention, storage temporary and evapotranspiration.
- Apply the appropriate sizing methods according to the hydrological contexts and urban.
- Integrate these solutions into a global approach to **integrated rainwater management (GIEP)**.

Introduction

In urban areas, the objective of alternative systems is no longer to evacuate water rainwater as far as possible from built-up areas, but to manage these volumes of water at the level of the area or watershed through storage structures, and possibly by a infiltration, and return them at low flow rate to the network or to the ground.

Comment ?

• Techniques alternatives :

- 1: Swales and ditches
- 2: Drainage trenches
- 3: Infiltration well
- 4: Reservoir structure roads
- 5: Storage roofs
- 6: Buried retention basin

• **Additional devices:**

- 7: Green roofs
- 8: Reed filters
- 9: Rainwater recovery (domestic use)



Figure 1: different alternative systems in stormwater sanitation.

IV.1 Sheet No. 1: SWELLS AND DITCHES

IV.1.1 Definition

Swales are wide, shallow ditches. They provide a definite landscape advantage.

IV.1.2 Operating principle

1. Introduction of rainwater: generally direct by runoff or conveyance by a driving;
2. Storage of water collected in the open air;
3. Evacuation of stored water by infiltration into the ground, and if necessary by a piped network, to a regulated flow.





Figure 2: Swales and infiltration ditches – devices for managing rainwater at source.

IV.2 Sheet No. 2: Drainage trenches

IV.2.1 Definition

Linear and superficial spaces filled with granular materials allowing water storage.

Operating principle

1. Introduction of rainwater: generally direct by runoff or conveyance by a driving;
2. Storage of water collected in a linear structure filled with porous materials;
3. Evacuation of stored water by infiltration into the ground, and if necessary by a piped network, to a regulated flow.



Figure 3. Drainage trenches .

<https://youtu.be/NEMRo18xM30>

IV. 3 Sheet No. 3: infiltration wells

IV.3.1 Definition

Structure of variable depth, allowing storage and direct evacuation of water to the ground rainwater (preferably from roofs).

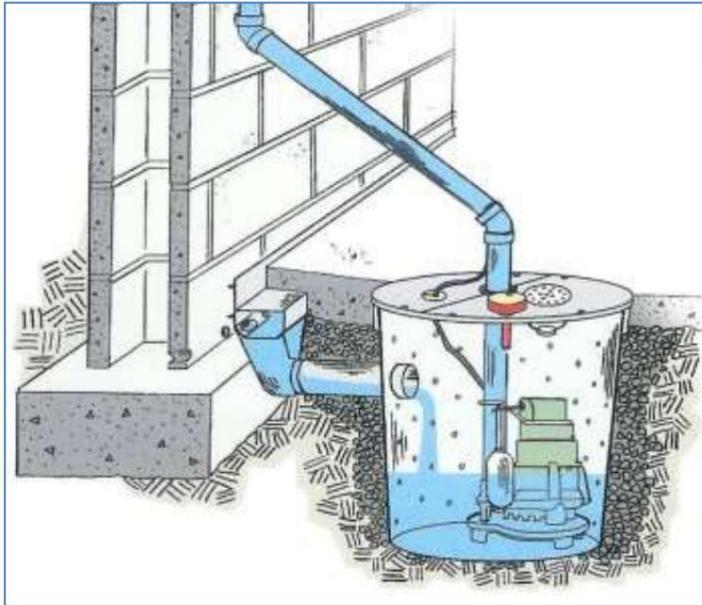
Operating principle

1. Supply by trickle or pipes
2. Temporary storage in the well
3. Evacuation of stored water by infiltration into the ground.



Figure 4: Schematic diagram of an infiltration well.

<https://youtu.be/ySdJR-YoQcw>



A **sump** (or infiltration well) has the following functions:
 objective **of evacuating the water present in your ground** to deeper layers in
 the ground, and therefore more permeable. Its depth and its diameter depend on multiple factors, such as soil composition, rainfall...

Figure 5: Example of an infiltration well – vertical infiltration of runoff water.

Sheet No. 4: Reservoir structure roads

IV.4.1 Definition

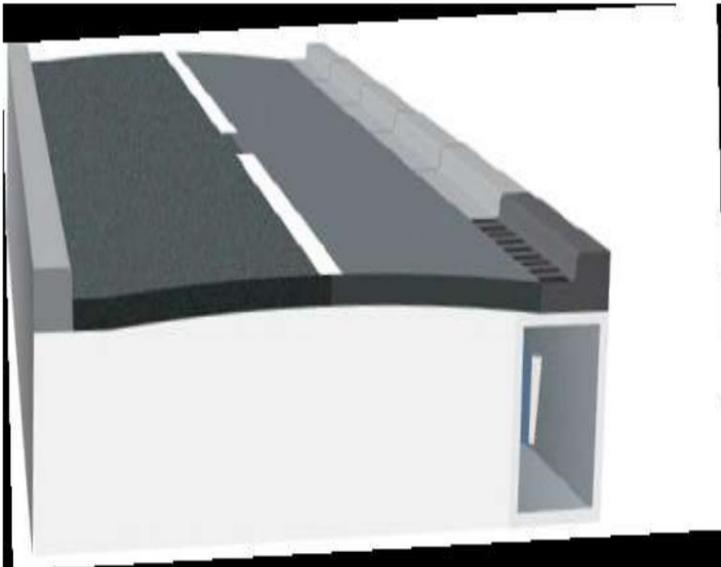
A road surface which has a layer at least 10 cm thick and made of a porous material, or draining with a porosity greater than 15%. These developments support traffic, and are mainly carried out in ZACs or subdivisions.

Operating principle

1. Temporary storage of runoff water collected in the body of the structure
2. If the coating is porous: direct infiltration into the structure; If the coating is waterproof: injection through drains
3. Evacuation of stored water by infiltration into the ground, and if necessary by a piped network, to a regulated flow.

<https://youtu.be/ff--mneiC9U>

<https://youtu.be/5kYLkGczIVQ>



Function: Store runoff water from parking lots, roads, sports grounds, etc. in voids.



Figure 6: Roadway with reservoir structure – principle of temporary storage of rainwater.

• Or ?

Low-gradient roads, avoid roundabouts and busy roads.

Sheet No. 5: Storage roofs

IV.5.1 Definition

Also called “flat roofs”, these are flat roofs with no or low slope, fitted with parapets around the perimeter allowing temporary storage of rainwater.

Operating principle

Temporarily store rainwater and return it to the network, ensuring a regulated flow rate thanks to a drainage device.



Figure 7: Storage roof – rainwater retention and regulation device.

Fact sheet no. 6: Earth retention basins

IV.6.1 Definition

Underground rainwater storage structure, with a regulated drainage system. For a large-scale use (housing development, etc.) under green spaces, roads or parking lots, or for the retention of small volumes in private homes (in this case the useful volume may include, in addition to the storage volume, a reuse volume).

Operating principle

The water is stored then evacuated to an outlet, guaranteeing a regulated flow.

<https://youtu.be/54kzXsy3gxl>

https://youtu.be/Uo_2dzKM9PA





Figure 8: Retention basin under construction – temporary storage of runoff water.

Fact sheet no. 7: Green roofs

IV.7.1 Definition

Also called “green roofs”, these are roofs covered with vegetation and various layers allowing its development.

Even if they contribute to reducing the volumes of runoff water and to the rolling of peak flows, they do not constitute a measure for retaining rainwater: in the event of water saturation of the roof and faced with a new rainy episode, the latter will have a behavior identical to that of a conventional roof.





Figure 9. Integration of a green roof into the architecture.

<https://youtu.be/N44gDBTJsNw>

IV.8 Hydraulic dimensioning: Retention and infiltration structures

This method allows a first approach to determine the volume of water rainwater which must be stored in a structure. It applies to the sizing of pits, swales, infiltration wells, trenches and reservoir structures. The method used is " *the rain method* "

The "method for calculating the volume of retention or infiltration works" presents usage limits:

- ÿ It can only be used for home improvement projects individual and less than 1 ha;
- ÿ It only takes into account rainwater falling on the plot;
- ÿ It does not take into account runoff water that comes from the exterior of the plot;
- ÿ It can only be used for urban surfaces;

ÿ The leakage rate from the storage structure is constant.

IV.8.1 Determination of leakage flow rate

Depending on water quality, soil permeability, pollution risk and the sensitivity of the environment and its uses, it is possible:

- ÿ Either to infiltrate rainwater into the plot, the leakage flow rate then corresponds to the soil's ability to infiltrate water.
- ÿ Either to discharge them into a watercourse or into the collective sanitation network, regulated flow (if infiltration is impossible or not appropriate).

IV.8.2 Infiltration

For water to infiltrate, the permeability of the soil (K in m/s) must be between 10^{-5} and 10^{-2} m/s.

With a permeability lower than 10^{-5} m/s, water infiltration is difficult or even impossible. To determine soil permeability, refer to the table below. To

check the infiltration of the plot, it is recommended to carry out a permeability test (Porchet test type).

Table 01: Orders of magnitude of hydraulic conductivity in different soils

K (m/s)	10 ⁻¹ 10 ⁻² 10 ⁻³	10 ⁻⁴ 10 ⁻⁵	10 ⁻⁶ 10 ⁻⁷ 10 ⁻⁸	10 ⁻⁹ 10 ⁻¹⁰ 10 ⁻¹¹
Types of alone	Gravel sable fine elements without in	Sable gravel, sand coarse to sand with END	Very fine sand coarse silt clayey Silt	Silty clay a homogeneous clay
Possibilities d'infiltration	Excellent	Good	Averages weak	Weak to zero

In the case of permeability higher than 10^{-2} m/s of the devices of pretreatment or filters must be put in place to prevent soil leaching. In this case, infiltration wells are strictly prohibited.

To determine the leakage rate, it is necessary to establish a surface area for the infiltration structure. This-
This can then be refined according to the final dimensions of the work.

IV.8.3 Infiltration surface of retention/infiltration basins

Only the horizontal background is taken into account.

Slopes are not considered in the initial sizing calculation (surface additional security that will be necessary after a few years of operation and clogging).

Leakage flow rate: $Qf = S \text{ inf (bottom of the basin)} \times K$

With: K , soil permeability (in m/s).

IV.8.4 Infiltration surface of swales and ditches

It corresponds to the mirror surface (horizontal projection of the work).

Leakage rate: $Qf = \text{Width} \times \text{Length} \times K$

IV.8.5 Infiltration surface of trenches and infiltration wells

We only take into account half of the vertical walls (we do not consider the bottom of these works which quickly clogs up).

Leakage rate: $Qf = 1/2 \times S \text{ vertical walls} \times K$

IV.8.6 Calculation of the volume of water to be stored for a discharge with limited flow or with infiltration:

To determine the volume of water to be stored before discharge, you need to know the coefficient input (C_a , coefficient which measures the overall yield of precipitation) as well as the surface active runoff (S_a) which will be connected to the storage structure.

IV.8.7 Determination of the runoff coefficient (C_r) and the input coefficient (C_a)

The runoff coefficient varies depending on the soil type. This is can be determined using the table below (from the "Technical Sanitation Guide" published by Le Moniteur).

Table 02: Runoff coefficient values depending on the soil type.

Nature of the surface		Runoff coefficient (Cr)
Impermeable	Paving, coated road, cement track	Between 0.7 and 0.95
	Roof and terrace	Between 0.7 and 0.95
	Impermeable soil with vegetation Slope < 2%	Between 0.13 and 0.18
	2% < pente < 7%	Between 0.13 and 0.18
	Slope > 7%	Between 0.13 and 0.18
Permeable	Permeable soil with vegetation Slope < 2%	Between 0.05 and 0.10
	2% < pente < 7%	Between 0.10 and 0.15
	Slope > 7%	Between 0.15 and 0.20
	Type of land use	Runoff coefficient
Impermeable	Industrial	Between 0.5 and 0.8

IV.8.8 Values of runoff coefficients depending on the nature of the surface and the type land use

The input coefficient (Ca) measures the overall yield of the rain (fraction of the rain which actually reaches the outlet of the watershed in question).

The overall input coefficient can be determined from runoff coefficients (Cri) of homogeneous surfaces (Si):

$$\sum C_{ri} S_i$$

$$C_a \text{ global} = \frac{\sum C_{ri} S_i}{S_{\text{total}}}$$

$$Stotale = \sum (Simper + Snonimper)$$

IV.8.9 Determination of the active surface area (Sa)

The active surface is the surface participating in runoff.

$$Sa = C_{global} \times S$$

With :

Sa: the active runoff surface (in m²). C_{global}: the input coefficient (without unit).

S: the total surface area of the project (in m²).

Conclusion

Alternative techniques make it possible to respond either curatively or preventively to flood risks. Curative measures generally intervene after a significant phase of urbanization and come to compensate for the repeated failures of networks responsible for flooding.

Preventive measures have a different mission since their objective is to maintain the hydrological conditions that define runoff processes.

These measures therefore accompany the spatial extension of urban areas and avoid the oversizing of networks downstream of newly built areas.

Alternative techniques are characterized by their ability to adapt to sites.

There are many options available to developers, but each type of structure has its own limits.

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