People's Democratic Republic of Algeria
Ministry of Higher Education and Scientific Research
University Center Abd El Hafid Boussouf Mila
Department of Civil and Hydraulic Engineering.

SANITATION COURSE HANDOUT

Dr. Boumessenegh Amel

- Sanitation course handout -

– 3rd Year Hydraulic License –

College year: 2023/2024

THE SANITATION GLOSSARY

Aa

- **Sanitation:** Underground network of installed pipes, allowing the collection and treatment of water. This ensures the proper functioning of the health situation.
- **Collective sanitation: Pipelines directly connected to the** collective sanitation network of the city/sewers.
- **Sewerage:** Pipelines not connected to the city's collective network. In this case the water treatment is done independently via a septic tank.

Bb

- **Grease trap:** tray for collecting and treating kitchen grease, preventing grease from flowing into the pipes and thus into the common network.
- **Cleaning nozzle:** Nozzle allowing the projection of a jet according to the defined shape in order to **unblock,** clean or clean the pipe.
- **Cleaning sludge:** residual sediments accumulated in pipes, which are removed by cleaning and pumping.
- **Accumulation basin:** Rainwater basin with an accumulation function (for example: hydroelectric dam).
- **Rainwater basin (BEP):** Sanitation structure intended to temporarily store excess urban water during rains before returning it to the downstream network in conditions acceptable to the latter or treating it in a WWTP.
- **Decantation basin:** Rainwater or wastewater basin with a decantation function. Basin in which suspended materials, whose specific weight is different from that of water, are separated from the liquid by sedimentation or flotation. The settled water comes out of the system, while the impurities are extracted in the form of sludge.
- **Retention basin:** Water basin allowing a retention function by limiting the flow at its outlet.

- **Watershed:** Area of the territory in which water discharges into a common converging point (chamber or section of pipe) of the network.
- **Nozzle:** conduit, pipe.

Cc

- . **Pipeline:** Set of pipes, tubes or conduits intended for the circulation of fluids by free flow or under pressure.
- **Clarification:** Water treatment process consisting of the separation of purified water and sludge resulting from the degradation of organic matter. Optionally added with a coagulation-flocculation step, the separation of the flocs formed is carried out by decantation, flotation, filtration or membrane treatment.
- **Coagulation:** Destabilization phenomenon caused by a physical (heat), chemical (acid, metallic salt, etc.), biochemical (enzyme) agent on a colloidal substance by suppressing intercolloidal repulsions and thus making flocculation possible.
- **Coefficient. Waterproofing:** Ratio between the waterproofed surface of a watershed and its total surface area.
- **Runoff coefficient:** Ratio between the intensity of a uniform downpour of a given duration and the maximum flow (Qmax). It takes into account the delay in flow resulting from the nature of the receiving surface.
- **Collector:** Transport channel collects rainwater wastewater. It has increasingly larger diameters in the direction of the current. It has various shapes and can be made of different materials. The collectors are of three types: circular (noted Ø or DN), ovoid (noted T, oval shape) or scuppers (noted D, rectangular or square shape).
- **Corrosion:** Attack on the surface of a metal due to electrochemical action in an aerated or non-aerated environment. Attack by physical action can cause erosion or abrasion. Attack on a non-metallic material is degradation.
- **Raised level:** Lowest point of a structure.
- **PVC elbow:** Available in many sizes and shapes, the PVC elbow allows connection between 2 installations.

- **Cleaning:** mechanical action allowing the cleaning of pipes using a sewer jetter truck.

Dd

- **Unblocking:** Action to remove a stuck or accumulated object/waste.
- **Decantation:** Separation of solids suspended in water.
- **Aerobic degradation:** natural degradation by air.
- **Flow:** Volume of water that flows at a given point for a given time. For permanent flows, the equation is: Q = VS, with Q = flow, V = average speed of the flow through the wetted section, S: wetted section.
- **Screen:** The role of the screen, generally installed at the entrance to a WWTP, is to retain bulky waste. The goal is to avoid clogging and physical deterioration of downstream structures.

Ee

- **Acidic waters:** Boiler room water, softener/air conditioner discharge.
- **Aggressive waters:** swimming pool water / sea water
- **Cooking water:** water containing fat.
- **Household water:** fat-free water containing fibrous materials.
- **Wastewater:** black water + gray water
- **Vanne Water:** Water containing fecal matter, fibrous residues and particles.
- **Gravity flow:** Water flowing in the direction of the slope of the pipe.
- **Flow in penstock:** Conduit under pressure of water in a pipe allowing its flow.
- **Effluent:** Term to designate wastewater.
- **Spreading:** Installation allowing pre-treated water from an all-water pit to be filtered into the ground.
- **Waterproofing:** Water-resistant coating or device.
- **Outlet:** Stage of the process, allowing the various flows to be collected and evacuated towards dedicated treatments.

Ff

- **Wax:** Subsidence or deformation of land or roadway creating a cavity in which water accumulates.
- **Float:** Installed on the lifting pump, it detects the water level in the pit and activates the lifting pump automatically in order to empty the pit.
- **Lifting pit:** Pit containing a lifting pump, allowing UW (user water) or RW (Rainwater) to be received from the home before being evacuated by the pump.
- **All-water tank:** Used to replace septic tanks, the all-water tank allows the pretreatment of all water combined, unlike the septic tank which can only accommodate sewage.
- **Septic tank:** Tank used to pre-treat the sewage from a home when the sanitation network is non-collective.

Hh

- **Hydraulic:** This uses the energy of water.
- **Hyetogram:** Diagram representing the intensity of precipitation as a function of time.
- **Max height profile:** Maximum interior height of a structure.

Ii

- **Rot-proof:** Insensitive to the action of bacteria.
- **Pipe camera inspection:** Small camera that can be inserted into pipes to search, locate and inspect a damaged pipe, a blockage or a leak.
- **Rain intensity:** Height of water precipitated per unit of time, expressed mm/h.

Mm

- **Natural environment:** Rivers, lakes, the sea, meadows, forests, but also groundwater (underground water reservoirs) fed by the infiltration (passage of water through the ground) of rainwater.
- **MES:** Suspended solids. These are the solid substances present in water, measured by decantation, centrifugation or membrane filtration. Eaux uses the term total undissolved substance.
- **Single-phase:** Electric circuit having only one phase. Allows power at low power.
- **Receiving environment:** Surface or underground aquatic system receiving discharges.
- **Rain model:** Theoretical rain event with variation in rain intensity over a chosen duration.

Nn

- **Water table:** Source of natural underground water.
- **Neutralization:** Process which consists of bringing a solution to a defined pH (generally between 6.5 and 9.0): by acidification if its initial pH is higher and by alkalinization if it is lower.
- **Nitrification:** Oxidation of ammonia to nitrates. This reaction is carried out in two successive stages and by two different bacterial populations: nitritation, which is the (slow) transformation of ammonia into nitrites, then nitratation, which is the (rapid) transformation of nitrites into nitrates.
- **Network node:** Hydraulic reference point of the evacuation network, such as a chamber which is the connection between two sections.

Pp

- **Permeability:** Who allows water infiltration.
- **Rainfall:** Measurement of precipitation indicating in Liters the quantity of rain that fell.
- **Pumping:** Action allowing a liquid to be sucked up
- **Lifting pump:** installation allowing fluids to be lifted using a motor when the sanitation network is larger than that of the building.

- **Sump:** Drainage installation allowing rainwater to be collected and thus evacuated naturally into the ground by a drainage action.

Rr

- **A Radier:** Small stream of water allowing the flow of effluent in a pipe.
- **Backflow:** Too much water in the pipes, creating a flood going up through the drains of homes.
- **A Look:** Generally buried, it allows rainwater or wastewater to be collected. Equipped with a hatch, it is accessible for maintenance on the sanitation network.
- **One-eyed look:** Is installed as an intermediary for safety in the event of problems on the sanitation network but is neither accessible nor visible.
- **Sanitation network:** All the works which allow rainwater and wastewater to be evacuated into pipes.
- **Separative network:** Network which separates rainwater and wastewater using different pipes.
- **Unitary network:** Network which brings together rainwater and wastewater in the same pipe.
- **Ru:** Stream, small rivulet of water.

Ss

- **Sewage/sanitation plant:** station where all sewer water is transported and treated in its entirety.
- **Residual sediment:** Sludge created by waste and bacteria present in the water.
- **Siphon disconnector:** Siphon to prevent the rise of odors due to drafts of air present in public networks.

Tt

- **Buffer / Manhole cover:** Plates present on the road, allowing access to the sewers.
- **Down the drain:** When all the water from the sanitation network is discharged into the sewer. (Collective network)

- **Spreading Hose:** Proportionally distributes water for a spreading installation.

- **Isolation valve:** device installed on a pipe allowing flow to be controlled.
- **Emptying:** Action of emptying and cleaning dirty bodies from a container (a septic tank, a grease trap).
- **Suction cup:** Device (rubber washer) which attaches by partial vacuum to a surface in order to unclog.

FOREWORD

Sanitation **is** an approach aimed at improving the overall health situation of the environment in its various components. It includes the collection, treatment and disposal of liquid waste, solid waste and excrement.

Environmental sanitation aims to protect and promote human health and well-being by providing a clean environment and breaking the cycle of disease.

The discharge of wastewater into the environment always presents the risk of polluting groundwater and further aggravating the difficulties of supplying drinking water. It is mainly the sanitation issues of homes not yet connected to the sewer system that will pose a problem in the years to come. This is therefore clearly a problem of bringing existing housing up to standard.

In this work, we will focus on treating sanitation as a whole. This handout is arranged in six chapters. **The first chapter** covers a history of sanitation, the general characteristics of the water to be discharged, as well as the reuse of wastewater.

We will then present in the **second chapter** the modes and systems of sanitation, the choice of the sanitation network, and the types of water evacuation, as well as the criteria for choosing between sanitation systems.

The third chapter will be devoted to the dimensions of the sanitation network, which includes the determination of the flow rates of rainwater and wastewater by several methods.

In the **fourth chapter ;** We present the conditions of water transport, the method of calculating a sanitation network whether it is a separative or unitary network, and the hydraulic calculation of the network; which includes the determination of diameters, the calculation of flow rates and flow speeds.

The fifth chapter, The main works of the sanitation network constitute the essential elements, which allow the collection, transport and treatment of waste and rainwater. They play a crucial role in protecting public health and the environment by ensuring effective wastewater management. These structures, well designed and maintained, guarantee the efficiency of the sanitation network and the protection of the environment against water pollution.

The ancillary works of the sanitation network are the subject of the **sixth chapter;** the elements of the sanitation network share the different types of manholes and their operation, storm overflows, lifting stations, retention basins, and finishing with the last element which is the gutter.

These ancillary works are essential to ensure optimal operation of the sanitation network. They contribute to environmental protection, public safety and the sustainability of sanitation infrastructure.

INTRODUCTION

We call “sanitation” all the water evacuation equipment from a building: rainwater (RW) and wastewater (UW). The latter includes household water (from sinks, washbasins, bathtubs, washing machines, etc.) and sewage from toilets.

Each type of water is transported to the external collectors (sewers) by pipes, sized according to the discharge load that will be sent to them. This load is calculated either from a peak flow (a formula which involves water discharges, per inhabitant and per day, corresponding to the highest consumption of the year), or directly from data from facilities in the building.

The objective of this course is to enable the student to acquire knowledge of the different methods of sanitation, the types of existing network, and the sizing of the sanitation network as well as the associated works.

Through a clear methodological approach taking into account new technologies, important developments will allow the reader to find expected solutions. All of this copying will also give him the global vision essential to properly address any sanitation problem and prepare for the future.

In conclusion, sanitation is a fundamental pillar of sustainable development.

Concerted efforts and strategic investments are essential to ensure a future where every individual has safe access to adequate sanitation facilities.

List of paintings

Chapter I: General characteristics of the water to be evacuated.

Chapter III: Evaluation of the flow rates to be collected.

Chapter 4: Hydraulic calculation of the wastewater evacuation network

List of Figures

Chapter I: General characteristics of the water to be evacuated.

Chapter II: Sanitation systems and schemes

Chapter III: Evaluation of the flow rates to be collected.

Chapter IV: Hydraulic calculation of the wastewater evacuation network

Chapter V: Main works of the sanitation network

Chapter VI: The ancillary works of a sanitation network

SUMMARY

CHAPTER I GENERAL CHARACTERISTICS OF WATER TO BE EVACUATED

CHAPTER II SANITATION SYSTEMS AND SCHEMES

CHAPTER III EVALUATION OF THE FLOW RATES TO BE COLLECTED

CHAPTER IV HYDRAULIC CALCULATION OF THE WASTEWATER AND RAINWATER EVACUATION NETWORK

CHAPTER V MAIN WORKS OF THE SANITATION NETWORK

CHAPTER VI THE ANCILLARY WORKS OF A SANITATION NETWORK

Historique

Les civilisations évoluées les plus anciennes ont inventées un ensemble de techniques, et de moyens qui permet d'évacuer les déchets provenant des habitations et des activités humaines.

Chacun sait que l'on a retrouvé de remarquables réseaux d'évacuation dans les vestiges des constructions grecques et romaines.

En particulier ; celles du Proche-Orient qui contenaient des installations sanitaires avec des canalisations permettant l'arrivée et l'évacuation des eaux (Figure 1.01). [1]

Fig. I. 01. Sanitation system in the Near East in 1348. [**1]**

I.1 Brief history of urban sanitation

The first sewer systems were built in **ancient times** such as the famous **Cloaca Maxima** of ancient Rome 600 BC. JC (is a long canal, the main collecting sewer of ancient Rome. It combines three functions: rainwater recovery, evacuation... etc).

After the fall of the Roman Empire, sewer systems were gradually abandoned. Dirty water, feces and other household waste were then dumped directly and caused foul odors, contamination of well water and numerous diseases.

Following the successive epidemics of cholera which swept the world during the 19th century, the hygienist movement recommended in the 1850s the construction of buried sewer networks to evacuate dirty domestic water, rainwater and washing water streets directly into rivers or the sea.

The length of the City of Paris's sanitation network thus increased from 150 km in 1853 to nearly 900 km in 1890 (around 2,500 km currently). (Figure I.02).

In 1894, a law required Parisian buildings to discharge their waste and rainwater as well as their black water into the newly created sewer network (called unitary). The concept of sewerage thus appeared. [1]

Fig. I.02. Quai Voltaire, section of the quay collector, 1899.

It was only from the 1960s that separative networks were developed in new city districts and new towns to collect and treat domestic wastewater and rainwater separately. Wastewater produced by polluting industrial activities cannot be discharged directly into the sanitation network and must be decontaminated by industrialists.

The disposal of wastewater moved the problem of nuisances out of cities and generated increasingly unacceptable pollution of surface waters. The first purification techniques appeared in the 1860s with the spreading of raw wastewater on sandy soils in order to use the purifying power of the soil. [1]

I.2 Introduction

Water represents the enemy of the road, because it poses major multiple and complex problems on the roadway, which jeopardizes the safety of the user (slips, flooding, etc.).

So the purpose of the sanitation network is to collect runoff water; in order to avoid infiltration into the layers of the road body, it can also run off on the surface, this follows the direction of the transverse and longitudinal slope.

I.3 Definition

Sanitation: set of provisions allowing the collection, treatment and evacuation of residual water. There are two types of sanitation:

- **Collective:** residual water is evacuated into the sewers;

- **Non-collective:** residual water is treated and evacuated independently and on the site of its production (septic tank, all-water tank).

I.4 Objective of sanitation

- Avoid erosion problems.
- Ensure the evacuation and treatment of wastewater and rainwater
- Minimizing health and environmental risks
- Ensure the protection of property and people up to a certain intensity of rain.

I.4 C Classification of wastewater

Wastewater mainly consists of water from domestic, industrial and rainwater origins. Their composition depends on the organization of the urban fabric. Table I.1 gives the main elements contained in the discharged water. [2]

Table I.1. Elements contained in wastewater and rainwater

Wastewater: activity industrial	Wastewater: household activity	Rainwater: urban activity
Depends on type of industry	Sands from washing	Sand and gravel
	Plant waste (vegetables)	Dust
	Animal waste (meat)	Dead branches and leaves
	Fats and oils	Hydrocarbons
	Detergent (bleach, omo)	Drain oils
	Paper, plastic…etc.	Tar
	Chemical products	Objects of all kinds
	Object of any kind	

I.4.1 Rainwater (runoff water)

These are the waters coming from atmospheric precipitation (rain, snow, hail) which run off roofs, ground and facades.

Fig. I.03. Rainwater.

I.4.2 Wastewater

Are all waters which are likely to contaminate the environments, into which they are discharged, we distinguish:

- Wastewater falls into two main groups:
- Domestic wastewater
- Wastewater of industrial origin

I.4.2.1 Domestic wastewater

These are everyday waters. She understands:

- ✓ Gray water (gray water): This is dishwater, kitchen water, washing water, bath water, shower water and bath water. This water is evacuated through sinks, washbasins and bathtubs.
- ✓ Sewage water (the black ones): These are toilet waters (urine and feces).

  Each toilet consists of a WC and a flushing device, we distinguish:

- – The tank system incorporated at the bottom and top
- – The tap system
- – The flush system

– Sewage water contains fermentable material so it should be quickly released into the natural environment following its passage through the treatment plant.

I.4.2.2 Industrial wastewater

This water comes from manufacturing or processing plants. Depending on the type of industry, the waste released can be toxic to humans, fauna and flora. It is recommended to treat this water on site before discharging it into the sanitation network. [2]

Fig. I.04. Wastewater evacuated.

I.5 Characteristics of the water to be evacuated

Wastewater includes household water (kitchen, toilet, laundry, etc.); these are the only ones whose characteristics we will examine below, which are those of a polluted and harmful effluent (the characteristics of industrial waters in fact vary with each type of industry).

Wastewater constitutes a polluted and harmful effluent; the study concerns the biological and physicochemical point of view.

I.5.1 Qualities of domestic wastewater

I.5.1.1 Physico-chemical characteristics

Wastewater contains:

- Mineral materials
- Organic materials

a. Mineral materials

Mineral materials constitute the dry residue after heating all the materials collected after evaporation. They are not dangerous: MES500, that is to say a temperature of approximately 500°C is necessary to calcine these materials

b. Organic materials

Organic materials are those which are volatilized during heating under the same conditions. It exists in very small quantities or even in trace amounts: the elements which play an important role in the degradation or assimilation processes (example S, Fe, Cu, P) have MVS volatile matter in suspension These materials occur in three forms in domestic wastewater:

1. Suspended matter: For reasons relating to the purification of wastewater, a distinction is made between matter which can be settled in 2 hours (approximately 270 mg/l of organic matter and 130 mg/l of mineral matter) and non-settled matter (130 mg/l of organic matter and 70 mg/l of mineral matter).

2. Suspended solids that cannot be settled within 2 hours either because of their very fine particle sizes, their density close to water or even their colloidal state.

3. Dissolved materials:

Around 330 mg/l of organic matter and 330 mg/l of mineral matter.

These values are collected in Table I. 2.

Table I-2: average composition of wastewater

	Mineral materials	Organic materials	Total
Suspended matter			
Decantable in 2 hours.	130 mg/l	270 mg/l	400 mg/l
Not decantable in 2 hours	70 mg/l	130 mg/l	200 mg/l
Total	200 mg/l	400 mg/l	600 mg/l
Dissolved solids	330 mg/l	330 mg/l	660 mg/l
Total	530 mg/l	730 mg/l	1260 mg/l

All these concentrations depend on the quality of water consumed daily per inhabitant.

The particle size analysis gives:

a. Colloidal state=1micron
b. Dissolved state <0.1micron
c. Suspended state>1micron
d. Decantable state >100 microns

I.5.1.2 Biological characteristics

Wastewater contains all the germs from fecal matter, including pathogenic germs which disappear more or less quickly through vital competition.

It is recommended inside a hospital establishment to carry out the separation of wastewater and rainwater

Gray water is the source of certain product inputs which, in very small quantities, can play a very important and often harmful role in the progress of purification operations (detergent, hydrocarbon). [3]

I.5.2 Qualities of industrial wastewater

Industrial wastewater depends on the type of industry. It contains substances that may be acidic, corrosive or scaling.

Wastewater must meet the following water requirements:

1-the water must not be too hot 2-temperature to be respected t <30 or 35 degrees

2- They must not contain corrosive elements such as acids, bases which attack construction materials
3- Wastewater must not contain solid materials which may deteriorate by friction the walls of the pipes
4- They must not give off an unbearable odor
5- They must not contain volatile materials which poison the air in the pipes
6- They must not contain toxic or radioactive materials which make their treatment in wastewater treatment plants more difficult.
7- They must not harm the health of wastewater treatment plant supervisors [2] [3]

I.6 Wastewater reuse

Wastewater and sludge were used in agriculture or gardening, sometimes directly (including for livestock feed) without precaution and this is still the case in some countries.

Then legislation sought to limit the risks of parasitosis , the spread of water-borne diseases and chronic intoxication and sometimes due to unacceptable socio-cultural or religious phenomena; depending on the place and time, the reuse of wastewater is prohibited or subject to certain restrictions and authorizations, for health reasons (presence of pathogenic germs, heavy metals, pesticide residues or other undesirable products).

Conventional treatment of wastewater generally aims to decontaminate it sufficiently so that it does not alter the quality of the natural environment into which it will ultimately be discharged: rivers and seas.

Water from industries (effluents) and treatment plants can be used in a closed circuit, for cleaning, energy production (biomethanization) and heating. Another use is irrigation. The depolluted water can, in certain cases, even recharge the water table.

The main objective of wastewater reuse is not only to provide additional quantities of good quality water by accelerating the natural water purification cycle, but also to ensure the balance of this cycle and the protection of the surrounding environment. By definition, this reuse is a voluntary and planned action which aims to produce additional quantities of water for different uses in order to fill water deficits. [4]

I.7 Impact of wastewater reuse

The reuse of wastewater consists of recycling water considered unusable but which, depending on the area of reuse and following certain treatments, may be suitable for the following uses:

I.7.1 Agriculture

Despite significant modifications made to treatment plants to ensure the quality of wastewater; it can be used to meet irrigation needs in agricultural activities.

This has the advantage of allowing crops to benefit from the wealth of natural nutrients in wastewater, increasing soil productivity as well as allowing the practice of certain crops in regions where environmental conditions are not favorable, as in arid regions. Wastewater recycling represents a solution to meet the growing demand for water resources for irrigation.

On the other hand, the use of treated wastewater in agriculture can, however, pose problems for public health. Additionally, an irrigation project using wastewater as a source is not always economically profitable. [4]

I.7.2 Cleaning

Cleaning public roads and vehicles does not require the use of drinking water.

I.7.3 Environment

Discharge of treated wastewater concentrates can have environmental impacts. Excessive concentrations of chloride and sodium ions in discharged water can make plants toxic. [4]

CHAPTER II SANITATION SYSTEMS AND SCHEMES.

Introduction

The characteristics of the water to be evacuated (domestic and industrial wastewater and rainwater) present very different qualitative and quantitative aspects, so that different evacuation systems separating or not separating this water are technically possible.

There are basically two basic sanitation systems: The unitary system and the separative system. [5]

II.1 Sanitation methods and systems

Two methods of sanitation exist:

- ✓ **Collective sanitation:** made up of a public network for collecting and transporting waste and rainwater to a purification facility or an outlet.
- ✓ **Individual sanitation:** Any sanitation system carrying out the collection, pretreatment, purification, infiltration, or discharge of domestic wastewater from buildings not connected to the public sanitation network.

II.2 Definition of the various sanitation systems

The establishment of the network of an urban area must respond to two categories of concern, namely:

- Ensure correct drainage of rainwater so as to prevent submersion of urbanized areas, and avoid any stagnation after downpours.
- Ensure the evacuation of household wastewater, tap water, as well as industrial wastewater.

It made it possible to imagine one or more networks of pipes where the effluent generally flows by gravity.

The evacuation systems likely to be put into service are:

- Unitary system
- Separative system
- Pseudo-separative system
- Mixed system

II.2.1.Unitary system

This system allows the evacuation of wastewater and rainwater in the same collector, which therefore results in much larger evacuation and purification works.

This system is practical; because it requires only one connection per home. This system is generally oversized for the evacuation of peaks of rainwater; the operation of the treatment plant is compromised by the arrival of water from different origins with a different composition. [5] (figure II.1).

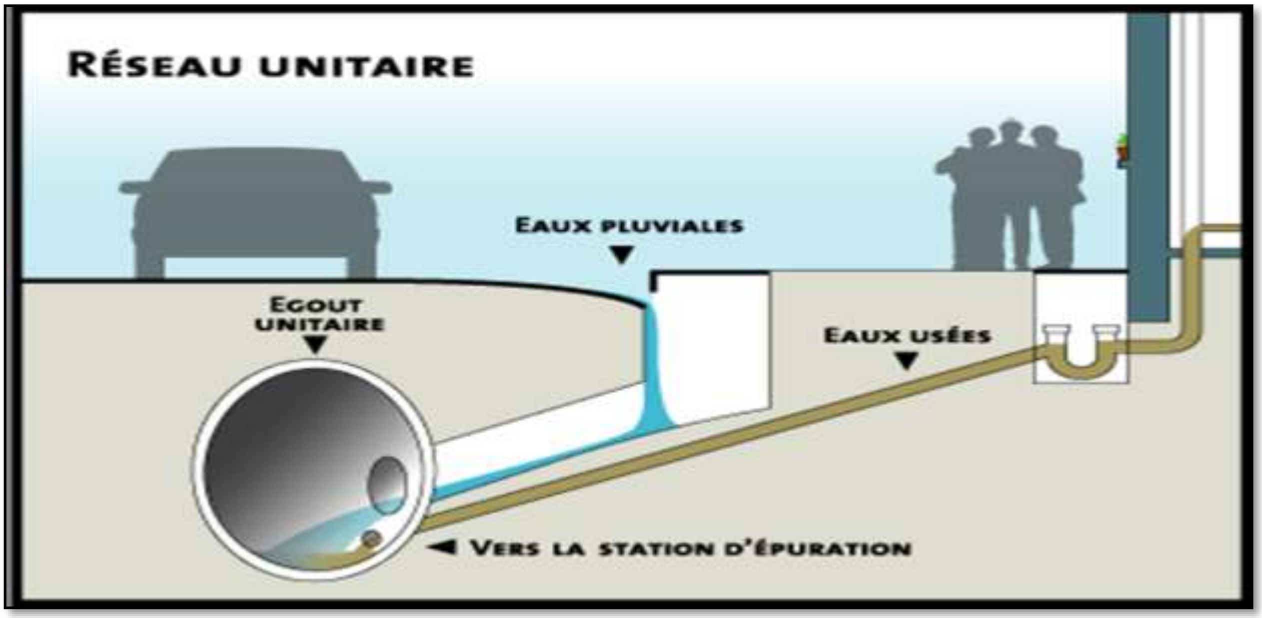


Fig. II.01. Unitary system.

A/-The advantages

• The simplicity

• Economy in design and maintenance

• There is no connection error

• Ease of realization

B/-The disadvantages

• Risk of pollutant deposits in dry weather

• Disruption of the operation of the treatment plant (due to variation in flow rates)

• Oversizing of the network (cumulative flow rates)

II.2.2 Separative system

This system provides for the evacuation of rainwater in a single pipe and the evacuation of domestic and industrial wastewater in another pipe.

- ***Rainwater Network :*** it is designed to evacuate rainwater, i.e. rainwater peaks; it follows the line of greatest slope. It transports the water to the nearest watercourses.

- **Wastewater network**: it is intended for the evacuation of wastewater of domestic and industrial origin to the treatment plant with a slope which may be slight. [4]

Fig. II.02. Separative system.

A/-The Advantages

- Possible discharge of rainwater into various outlets
- The treatment plant can simply be sized for the dry weather peak flow. This results in an economy.
- Since the composition of the wastewater is substantially constant, the plant can operate safely and efficiently.

B/-the disadvantages

- Self-cleaning problems at the head of the wastewater evacuation network
- Cost higher than unit
- The problems of connecting each building to two different pipes are difficult, and often lead to incorrect connections (i.e. wastewater in the rainwater network and vice versa).

II.2.3 Fundamental systems

II.2.3.1 Pseudo-separative system

It consists of evacuating wastewater of domestic and industrial origin into a pipe with a fraction of rainwater generally coming from roofs and private spaces, the other fraction is passed through gutters and rainwater structures. [2] [5]

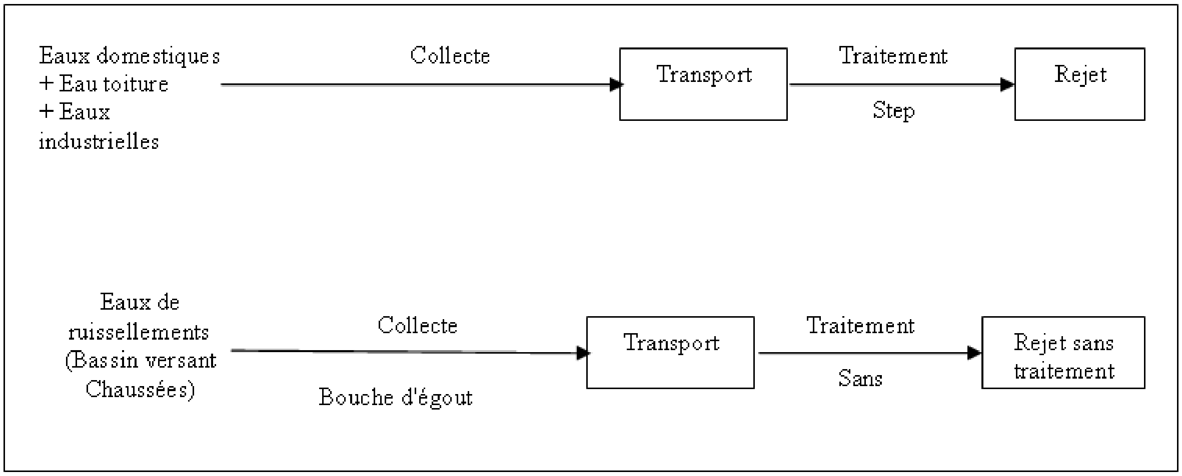


Fig. II.3. Principle diagram of a pseudo-separative network.

II.2.3.2 Mixed network

It is a system whose network is made up according to the residential zones, one part to the unitary system and another to the separative system.

II.2.3.3 The composite system

This system provides, through various arrangements, for a partial diversion of the most polluted water from the rainwater network to the wastewater network, with a view to their purification.

Knowing from experience that the first flood of rain and storm is supposed to have washed the public roads; in fact during this short period, runoff water always carries significant quantities of dirt.

II.3 Choice of sanitation network

The choice of network type must meet the following criteria:

- The type of system already existing and to which connection is possible.
- The cost of production
- The existence or absence of a wastewater treatment plant
- The topography of the land (gravity or pressure flow)
- Urbanization density: in an urban area with dense urbanization, the unitary system is generally the most used.

-It is preferable to use the separative network in regions with high precipitation.

II.4. Drainage network diagrams

Most often the urban area that we want to clean up is located near a river or a thalweg which allows final evacuation to be ensured, after possible treatment, and which indicates the general appearance of the reliefs controlling the orientation of the sewers.

II.4.1 Perpendicular diagram

The flow takes place directly into the watercourse. This type of scheme does not allow the concentration of water towards a single purification point and makes this difficult.

It can only be used for rainwater networks in separative systems with discharge into a watercourse. On the other hand, it allows a very economical route that does not require large sections.

Depending on the direction of the collectors in relation to that of the watercourse, we distinguish the perpendicular pattern. [5] (Figure II.4).

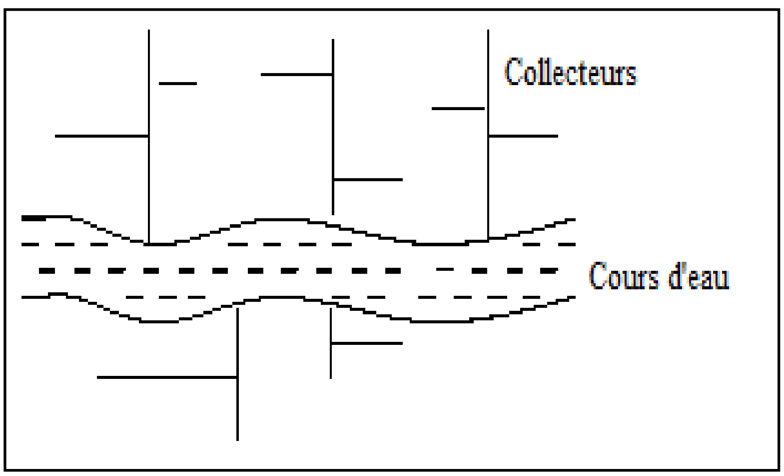


Fig. II.04. Perpendicular network.

II.4.2 Lateral movement equipment diagram

This type of route allows the water to pass through the same purification point by having a single collector lateral to the river, if the slope of the latter is sufficient. (Figure II.5).

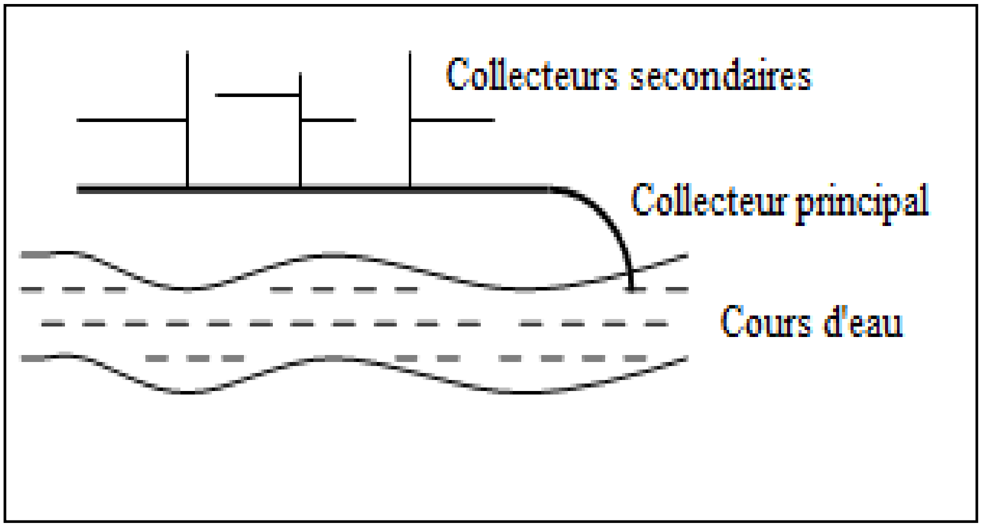


Fig. II.05: lateral collector network .

II.4.3 Staged collector equipment diagram

It is a lateral moving collector network with longitudinal secondary collectors. Network (2) is used to avoid overloading network (1). (Figure II.6).

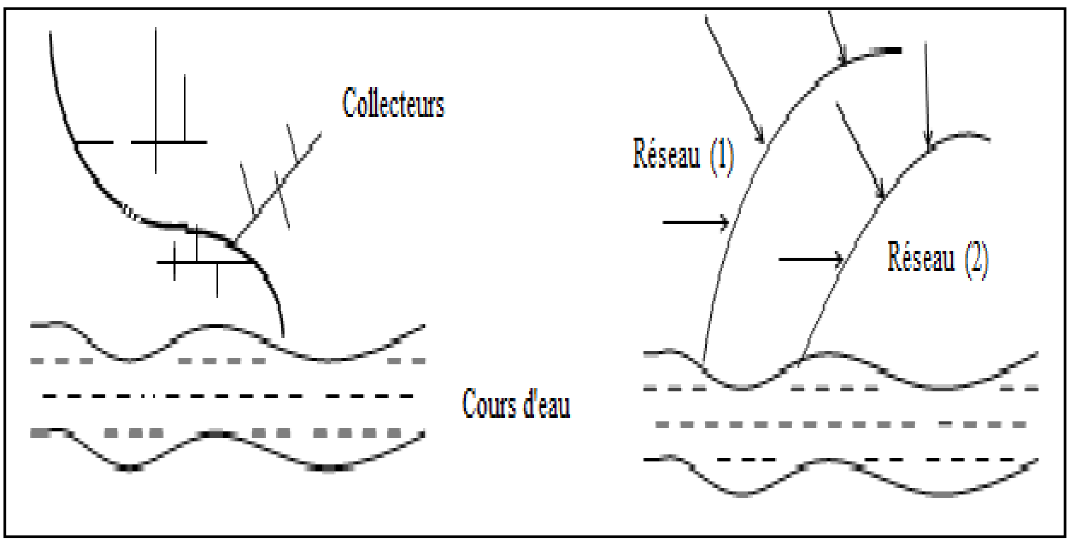


Fig. II.06: staged collection network.

II.2.4 Radial equipment diagram

This scheme is used in flat lands to collect all the effluent at one point through the following lifting. It is necessary for the transit of water to be evacuated towards the receiving environment. (Figure II.7).

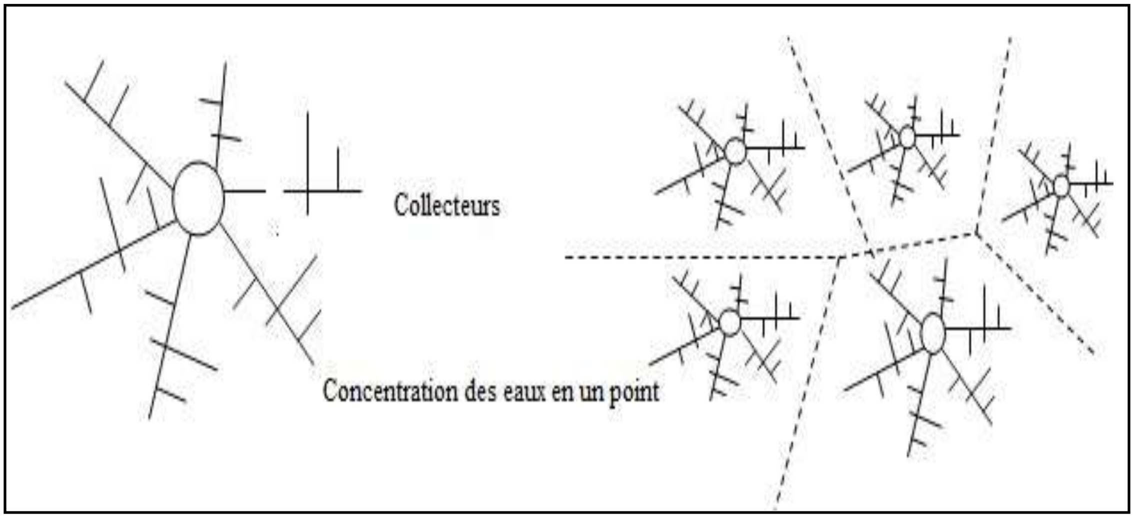


Fig. II.07: Radial equipment diagram .

II.3 procedures for calculating collectors

- Layout of the network in plan
- Cutting into sections of approximately 300 m
- Delimitation of the watershed drained by each section
- Calculation of the peak flow generated by this basin
- Wastewater peak flow
- Peak stormwater flow
- Calculation of the dimensions of the pipe based on its slope
- Drawing of the longitudinal profile of the pipe
- Checking correct operation

II.4 Criteria for choosing between sanitation systems

In general, the choice of a given evacuation system essentially depends on the objectives and constraints linked to the site such as:

1. Rainfall data;
2. Data relating to population growth and development;
3. Urban planning data: distribution of habitat...;
4. Data relating to the site: topography, nature of the soil, groundwater regime;
5. Economic and financial data;

6. The environmental aspect, linked in particular to the level of treatment tolerated when the Self-purifying power is limited;

7. Liquid Sanitation Master Plan for the city.

Reminder:

Assainissement = évacuation +épuration

Évacuation = ensemble des procédés permettant d'assurer la collecte et l'évacuation rapide des déchets.

Épuration = ensemble des traitements applicables à des déchets avant rejet dans un milieu naturel.

CHAPTER III EVALUATION OF THE FLOW RATES TO BE COLLECTED.

Introduction

After the use of drinking water, the so-called "waste" water is discharged into a network which must be able to evacuate at any time a flow rate substantially equal to that consumed without any risk of reflux.

III.2. Calculation of rainwater flows

The study of a rainwater sanitation network requires the determination of the flow rates to be evacuated. There are several methods of evaluating flow. The two most commonly used methods are [6] :

1. The rational method
2. The superficial method
3. The Mac-Math model
4. The Malet-Gauthier model, etc.

- The choice of an appropriate model depends on several factors:

- The area of the watershed
- The nature of the soil
- Slope
- The roughness of the works

III.2.1. The rational method

The rational method consists of estimating the flow rates from dividing the watershed into sectors (A_1, A_2, A_3,…, A_n) limited by isochronous lines.

Isochrones : "Which corresponds to the same instant" (or "to the same duration") , such as the water falling on sub-basin A_1 respectively A_2 ....A_n ; arrives at the outlet after Δt respectively $2\Delta t$....$n\Delta t$ (Figure III.1).

NB:

In hydrology , in the case of a watershed , an isochronous line is formed by all the points where a drop of water takes the same time to flow to the characteristic point of calculation (in general, the outlet) .

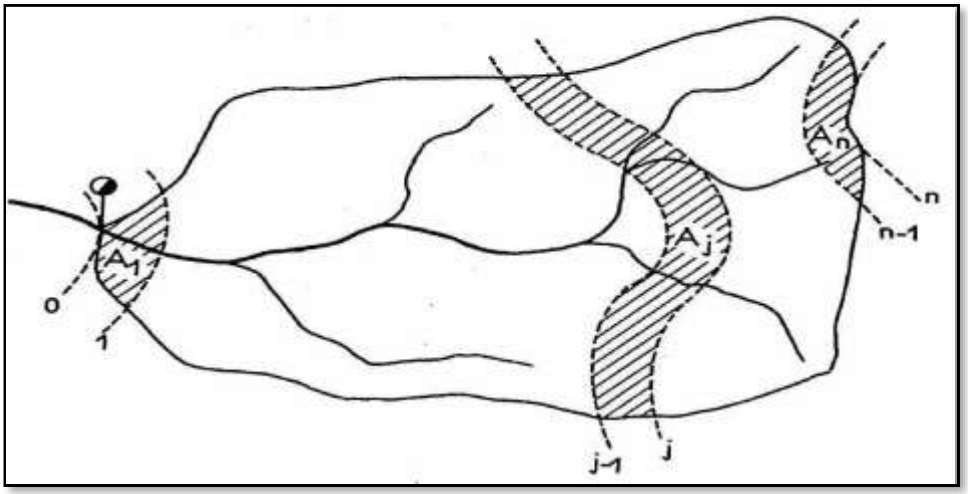


Fig. III.01: division of the basin into isochronous curves.

It is the oldest method, the most used, and easily applicable for small towns. The general formula is as follows [7] [8] :

$$Q = kCiA \quad \text{(III.01)}$$

With:

***Q*:** storm flow (m^3/s)

***k*:** intensity correction coefficient taking into account rain in space, the determination of which depends on the elongation of the basin

C: runoff coefficient specific to the sub-basin

***A*:** area of the basin (ha)

I: maximum intensity of rain (in l/s/ha)

Setting parameters

- ***Watershed (A)***

The watershed is defined as the collection area, which collects runoff water, it concentrates it towards the exit point called an outlet.

A watershed is characterized by its surface area, its average slope, its hydraulic length and its runoff coefficient.

The division of the watershed depends on the type of sanitation system chosen.

For separative and unitary systems, the division includes the roof and road surface, on the other hand for the pseudo-separative system; it includes the right of way, car parks and green spaces.

- **Watershed division**

The division into watersheds consists of determining for each section the area that must be cleaned up.

To divide the basin into elementary sub-basins (surface of influence), it is necessary to take into consideration:

- Level curves
- Natural boundaries (wadi, thalweg, etc.)
- The nature of the soil
- The density of inhabitants
- Roads and highways
- The slope of the land

- **Surface area of watersheds:** the evaluation of surfaces is done by cutting them into simple geometric shapes.

- **The return period of the rain event**

Sanitation works must ensure a sufficient degree of protection against flooding or pressure on the networks.

The degree of protection to be ensured is a compromise between the aspiration for absolute protection, which is economically unachievable, given the random nature of rainy events, and the concern to limit the cost of the investment. [5]

We are thus led to appreciate the more or less exceptional character of storms by their frequency of excess F, or by their return period T = 1 / F.

The choice of the return period is made by the competent authority (generally the project owner) based on:

• The risk for local residents;

• The risk for the environment of the structure;

• The risk for the work;

- **The runoff coefficient C_r**

It is the ratio of the volume of water, which flows over a surface, to the volume of water falling on this same surface.

It has a leading role in the evaluation of peak storm flows; which are used for network sizing. Its value varies from 0.05 to 1, it depends on several factors:

✓ The nature of the soil

- ✓ The slope of the land
- ✓ Land use
- ✓ Population density
- ✓ Rain duration
- ✓ Air humidity

We can say in general that the runoff coefficient is considered to be the waterproofing rate of the sub-basin.

$$C_r = \frac{A_{imp}}{A_t} \qquad \textbf{(III.02)}$$

With:

A_{imp} : Waterproof surface,

At_t : Total surface area of the sub-basin

The following approximate values are used:

Table III.01: Runoff coefficient depending on the zone of influence.

Area of influence	**Cr**
Totally impermeable surface (roofs, roads, sidewalks, etc.)	0.90
Wide joint paving.	0.60
Unpaved roads and macadam	0.35
Gravel driveways	0.20
Wooded areas	0.05

Table III.02. Runoff coefficient according to urbanization categories.

Very dense urbanization zone	Runoff coefficient
Dense residential area	0.90
Less dense housing area	0.60 – 0.70
Housing area	0.40 – 0.50
Residential neighborhoods	0.20 – 0.30
Squares, gardens, meadows	0.05 – 0.20

Table III.03: Runoff coefficient as a function of Population density.

Population density	Cr
20	0.23
30 – 80	0.20 – 0.27
80 – 150	0.25 – 0.34
150 – 200	0.30 – 0.45
200 – 300	0.60 – 0.62
300 – 400	0.60 – 0.80
400 –600	0.70 – 0.90
600 – 700	0.70 – 0.90

Table III.04: Runoff coefficient AS a function of slope.

Slope I	Average runoff coefficient		
%	culture	wooded land	rocky terrain
0 ≤I ≤10	Cr = 1.5 I	Cr = I	Cr = 2 I
10 ≤I ≤20	Cr = 0.05 + I	Cr = 2/3(0.05 + I)	Cr = 4/3(0.05 + I)
I > 20	Cr = 0.15 + I/2	Cr = 2/3(0.15 + I/2)	Cr = 4/3 (0.15 + I)

- **Determination of the weighted runoff coefficient .**

In the case where the surface of the basin considered is made up of several food areas “Ai” to which the runoff coefficients “Cri” are assigned, the weighted runoff coefficient is calculated:

$$C_{rp} = \frac{\sum C_{ri} A_i}{A_t} \qquad \textbf{(III.03)}$$

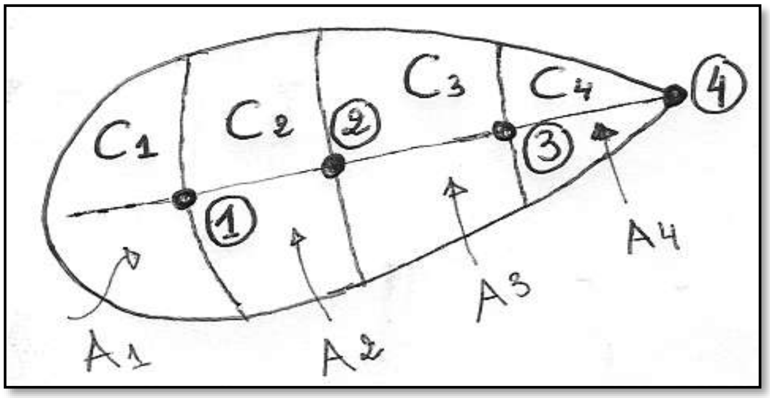
With:

C_{rp} : Weighted runoff coefficient

A_i : Elementary surface

C_{ri} : runoff coefficient corresponding to A_i .

<u>Example</u>



$C_1 = 0.20$; $At_1 = 2ha$

$C_2 = 0.3$; $At_2 = 1.5ha$

$C_3 = 0.05$; $At_3 = 1.8ha$

$C_4 = 0.10$; $At_4 = 2.5ha$

Find Ceq

Solution:

- At point 1

$C = C_1 = 0.20$

- At point 2

$C = C1 * A1 + C2 * A2 \div A1 + A2$

$= 0.24$

- At point 3

$C = C_1 * A_1 + C_2 * A_2 + C_3 * A_3 / A_1 + A_2 + A_3$

$= 0.18$

- At point 4

$C = C_1 * A_1 + C_2 * A_2 + C_3 * A_3 + C_4 * A_4 / A_1 + A_2 + A_3 + A_4$

$= 0.15$

- **Rain intensity**

The average precipitation intensity is the height of water that fell during a unit of time.

Determination of intensity

The intensity is expressed as a function of parameters **a** and **b** using the "Montana" formula: [4]

i (T, F) (mm/h) = a. tc $^{-b}$ **(III.04)**

a and b Montana parameter function of rainfall valid for a return period T and a given rain duration tc.

Note = MONTANA coefficients vary depending on the region and the return period.

Example :

T = 10 years (10-year rain)

Time interval tc = 15 mm

- Regional values of a and b:

a = 6.7 b = 0.55

i = 1.51 mm/h

- **Concentration time**

Concentration time is defined as the time required for a water particle to travel the longest hydraulic path from the basin boundary to the outlet

Depending on the characteristics of the drained basin, the concentration time is estimated respectively according to:

a) VENTURA (Ray)

$$T_c = 76,3\,\frac{(S_{BV})^{0,5}}{I^{0,5}} \qquad \text{(III.05)}$$

. Tc: concentration time (in min)

A: catchment area (km²)

I: average slope of the basin (%)

Validity range between 1 and 20 km² or greater than 10 km² depending on the works.

b) SOKOLOVSKY's formula

$$T_c = 4\left[\frac{(S_{Bv} * L_{Cp})^{0,333}}{\sqrt{I_{Bv}}}\right]^{0,75} \qquad \text{(III.06)}$$

With:

I_{BV} : The slope of the watershed in (m/km)

L_{CP} : Length of the main watercourse (Km)

S_{BV} : The area of the watershed (Km ^{2}

c) (Soil Conservation Service) formula

$$tc = \left[\frac{0,87 * Lp^3}{H}\right]^{0,385} \qquad (III.07)$$

H: Difference between the extreme points of the thalweg (m)

Lcp: Length of the main thalweg (Km).

tc: Concentration time in hours.

Note: It is complicated to find the range of validity of concentration time formulas, especially since depending on the literature, for the same formula, the validity times vary.

The Tc of an urban watershed is the longest time it can take for water flowing in that watershed to reach the sewer outlet. The entry time value is based on:

- The average slope of the land surface towards the manhole.
- The distance that the water must travel, on the surface, to reach the manhole.
- The nature of the surface over which the water must flow

Tc = Te+ Tf(III. 08)

Te: The access time of the water flowing over the surface to reach the manhole (entry time) or the longest time.

Tf: The flow time of water along the sanitation network depends on the flow speed.

To note that:

• For end sections:

We take: Te = 5min, Tf= L/60*Ve

• For intermediate sections:

$$\boldsymbol{Ti} = \mathbf{T}(\mathbf{i}-\mathbf{1}) + \frac{\boldsymbol{Li}}{\mathbf{60} * \boldsymbol{V}(\mathbf{i}-\mathbf{1})} \qquad (\mathbf{III.09})$$

Concentration time consists of:

1. From t_1 : put by the water to flow in the pipes. $\mathbf{t_1} = \frac{\mathbf{L}}{\mathbf{V}}$
2. From t_2 put by the water to reach the first engulfment structure. $\mathbf{t_2 = Ip^{-11/4}}$
3. Of t_3 time of runoff in a basin which does not have any pipes. $\mathbf{t_3} = \frac{\mathbf{L}}{\mathbf{11\sqrt{Ip}}}$

Concentration time can therefore have three aspects:

The basin does not have any pipes: $\mathbf{tc = t_3}$

The basin has a superficial route then a pipe: $\mathbf{t_c = t_3 + t_1}$

The basin is urbanized and has a main pipeline and tertiary connections: $\mathbf{tc = t_2 + t_1}$

III.2.1.1 the assumptions of the rational method

The following hypotheses therefore:

- The peak flow is proportional to the average intensity of the downpour over the concentration time.
- The intensity of the downpour in mm/h is uniform, in time and space, over the entire drained basin
- The peak flow Qp in m^3/s of the runoff hydrograph is a function of the precipitated flow i.
- Finally, the runoff coefficient is invariable from one downpour to another.

III.2.1.2 Calculation procedure

1. Divide the basin into elementary sub-basins corresponding to junctions of sections, Change of direction;
2. Evaluate and calculate the different parameters
3. Calculate the cumulative surface areas multiplied by their corresponding runoff coefficient
4. Evaluate the flow and consider the maximum flow.

III. 2.1.3 Validity of the rational method

This method is used for limited areas (generally less than 10 ha) the result is even lower due to the good estimation of the runoff coefficient, so it is applicable for areas where the concentration time does not exceed 30 minutes.

On the other hand, it is not likely to be used only for large areas due to the length of calculations to which it would lead [8].

III.2.2 The superficial method

This method is proposed by Mr. CAQUOT who developed a formula including all the data involved in the formulation of runoff points, including climatic coefficients. [8]

The most recent studies confirmed by experimental verifications have made it possible to fix the numerical value of the coefficients of this expression:

$$\boldsymbol{Q_p = k^{i/u} I^{v/u} C^{i/u} A^{w/u}} \qquad \textbf{(III.10)}$$

$$Q_{brut} = k^{1/u} \cdot I^{v/u} \cdot C^{1/u} \cdot A^{w/u} \qquad K = \frac{0{,}5^b \cdot a}{6{,}6} \qquad u = 1 + 0{,}287 \cdot b \qquad v = -0{,}41 \cdot b \qquad w = 0{,}95 + 0{,}507 \cdot b$$

K: characteristic coefficient **a** and **b** : are the Montana coefficients, a>0, b<0

In this expression all the parameters are functions of a(F) and b(F) which are themselves linked by the relation: $i(t,F) = a(F)\ t^{\ b(F)}$

With :

i(t,F): maximum rain intensity of duration (t in minutes is between 5 min and 120 min) and frequency (F)

Q_p : rain flow (m^3/s)

I: average slope of the basin (m/m)

C: basin runoff coefficient

A: basin surface area (ha)

K: expression coefficient: $K = 0.5^{\ b(F)} . \alpha(F) /6.6$

U: expression coefficient U = 1 + 0.287 b (F)

V: expression coefficient V= -0.41 b (F)

W: expression coefficient W = 0.95 + 0.507 b (F)

This formula is valid for watersheds of average elongation "M= 2"

Table III.05: the different forms of the formula depending on the return period.

Return period	**The formula**
10 years	$Q = 1.430\ I0.29\ Cr^{\ 1.20}\ A^{\ 0.78}$

5 years	$Q = 1.192\ I^{0.30}\ Cr^{1.21}\ A^{0.78}$
2 years	$Q = 0.834\ I^{0.834}\ Cr^{1.22}\ A^{0.77}$
A year	$Q = 0.682\ I^{0.32}\ Cr^{1.23}\ A^{0.77}$

For the region would meditate and a return period of 10 years the previous formula is written

$$\mathbf{Q = 1.29\ I^{0.21}\ Cr^{1.14}\ A^{0.83}} \qquad (\mathbf{III.11})$$

III.4.2 Elongation coefficient

The elongation coefficient **M** is considered to be the ratio between the length of the longest hydraulic path **L** and the side of the square of the surface equivalent to that of the basin considered [8].

$$\boldsymbol{M = \frac{L}{\sqrt{A}}} \qquad (\mathbf{III.12})$$

With:

A : the surface area of the sub-basin (ha)

This coefficient is intended to give a certain precision in the evaluation of the flow.

If the value of the coefficient **M** is different from **2** the flow will be corrected by a correction factor **m** which is given by the formula:

$$\boldsymbol{m = \left[\frac{M}{2}\right]^{[0.84\,b(F)/(1-b(F)F)]} = \left[\frac{M}{2}\right]^{[-0.42]}}$$

With:

M: elongation coefficient

b(F): parameter for expressing rainfall.

f: the peak flow adjustment factor in the concentration time expression.

(F= - 0.287).

Q_p corresponds to a raw value; this must take into account the coefficient **m** of the shape of the basin.

$$\mathbf{Q_{p\ corrected} = m\ Q_{praw}} \qquad (\mathbf{III.13})$$

III.3 The hypotheses and the basis for calculating the model

The method is also based on three hypotheses which are:

- The peak flow can only be observed at the outlet if the downpour has duration at least equal to the concentration time.
- The peak flow is proportional to the average intensity of the downpour over the concentration time.
- The peak flow of the same return period as the intensity that causes it

III.4. The application of the CAQUOT model

- The network must not be loaded for maximum flow rates because the CAQUOT model makes it possible to determine the maximum flow rates circulating in the various sections.
- The total surface area of the pool must be less than200 ha
- The runoff coefficient must be between 0.20 and 1.00
- The slopes will be between 0.002 and 0.05 m/m
- When it comes to assembling elementary basins, the ratio of the minimum and maximum slopes must not exceed 20
- The elongation coefficient must be greater than 0.8

III.5 Evaluation of equivalent parameters of a group of basins

The superficial formula developed above is valid for a pool of homogeneous physical characteristics. The application of the model to a group of heterogeneous sub-basins with individual parameters Aj, Cj, Ij, Lj (length of the main drain), Qpj (peak flow of the basin considered alone), requires the use of equivalence formulas for the parameters “A, C, I and M” of the grouping. [8]

These formulas, which differ depending on whether the basins constituting the group are in *"series"* or *"parallel"*, are expressed below:

Table III.6: Characteristics of each sub-basin grouping:

Serial assembly	**Parallel assembly**
$A = \sum_{i=1}^{N} Ai$	$A = \sum_{i=1}^{N} Ai$

$Creq = \dfrac{\sum_{i=1}^{N} Cri.Ai}{\sum_{i=1}^{N} Ai}$	$Creq = \dfrac{\sum_{i=1}^{N} Cri.Ai}{\sum_{i=1}^{N} Ai}$
$Iéq = \left[\dfrac{\sum_{i=1}^{N} Li}{\sum_{i=1}^{N}(\frac{Li}{\sqrt{Ii}})}\right]^2$	$Iéq = \left[\dfrac{\sum_{i=1}^{N} IQi}{\sum_{i=1}^{N} Qi}\right]$
$M = \dfrac{\sum L_j}{\sqrt{\sum A_j}}$	$M = \dfrac{L}{\sqrt{\sum A}}(Q\max)$

III.6 Evaluation of domestic wastewater

The evacuation of wastewater flows essentially concerns the estimation of the quality of liquid discharges coming from homes and places of activity

III.6.1 Average loss

1st method: Domestic water constitutes a significant part of the flow to be evacuated; this flow is calculated based on the average flow of drinking water. [7]

$$Q_{moyeu} = KQ_{moyAep} \qquad \textbf{(III. 14)}$$

With:

Q_{hub} : the average flow rate of wastewater.

Q_{moyAep} : the average flow of drinking water.

K: coefficient which represents the percentage of consumed water which will be evacuated

K = 70 – 80%.

- We take 70% Q_{avgAep} in the case of a rural region.
- We take 80% Q_{avgAep} in the case of an urban region.

The 20 – 30% represents the loss of drinking water in pipes, infiltration, street washing, watering gardens…..

The flow of drinking water is calculated by:

$$C_{moyj} = \frac{P_f d}{1000} \qquad ({m^3}/{j}) \qquad \textbf{(III. 15)}$$

With:

C_{avg} : average daily consumption.

d: the endowment (the water need for an inhabitant l/d/inhabitant).

P_f : future population.

2nd method:

The wastewater flow rate can be estimated directly from the average wastewater production (d').

$$Q_{moyeu} = \frac{P_f d'}{86400} \qquad ({l}/{s}) \qquad \textbf{(III. 16)}$$

With:

d ' : average production of wastewater (l/d/inhabitant) it is given by the following table:

Table.III. 07: average production of wastewater depending on the number of inhabitants.

Number of living	d(l/d/inhabitant)
>2000	100
2000 – 5000	115
5000 – 10,000	125
10,000 – 20,000	145
20,000 – 100,000	160
< 100,000	190

3rd method:

If we do not have the number of inhabitants, we can use the notion of population density. So the number of future inhabitants:

$$P_f = dA \qquad \textbf{(III. 17)}$$

With:

d: density (inhabitant/dwelling/ha)

A: total area (ha)

III.6.2 Peak wastewater flow

The flow of waste water is not constant; it varies according to the seasons, days, hours. To calculate the maximum flow rate passed through the sewerage network, it is therefore appropriate to assign the average flow rate to a point coefficient [7].

$$Q_{peu} = k_p Q_{moyeu}$$

Generally the peak coefficient is estimated by the relation:

$$K_p = 1.5 + \frac{2.5}{\sqrt{Qmoydomesmaj}} \qquad \text{(III.18)}$$

If Qmoy ≥ 2.8 l/s Kp = 3

- **Wastewater from equipment:** Different public services are called equipment: educational, health, tourist, administrative and various other public utility services. The estimate is based on the number of people who attend the place and on the allocation required for each activity, for example: – Schools: 10 l/day/student. – CEM: 15 l/day/student. – Shower: 50 l/client. – Mosque: 20 l/faithful.

Application:

Or two residential sectors:

- At $_1$ = 10 ha with an average density of $_1$ = 80 housing/hectare.
- A $_2$ = 15 ha with an average density of $_2$ = 30 housing/hectare.

If we consider that:

- The average occupancy density is D = 7 inhabitants/dwelling.
- The average needs distributed to each inhabitant (endowment) d $_1$ =150l/d/inhabitant, d $_2$ =200 l/d/inhabitant respectively the sector S_1 and S_2
- Losses are of the order of 20% of the value of needs.

Calculate the average flow and peak flow of wastewater for each sector and the flow of water to be evacuated.

Solution :

Sector 1:

- The number of housing NL = $_1$ * A $_1$ = 80 * 10 = 800 housing units.

- The number of inhabitants N $_p$ = N $_L$ * D = 800 * 7 = 5600 inhabitants.
- Drinking water flow:

$$Q_{moy\ Aep} = \frac{N_p * d}{86400} = \frac{150 * 5600}{86400} = 9.72\ l/s$$

The average wastewater flow:

$$Q_{moy\ eu} = 80\ \%\ Q_{moy\ Aep} = \frac{80}{100} * 9.72 = 7.77\quad l/s$$

Peak wastewater flow:

$$Q_{p\ eu} = k_p Q_{moy\ eu}$$

$$k_p = 1.5 + \frac{2.5}{\sqrt{Q_{moy\ eu}}} = 1.5 + \frac{2.5}{\sqrt{7.77}} = 2.39$$

$$Q_{p\ eu} = 2.39 * 7.77 = 18.62\quad l/s$$

Sector 2:

- The number of housing NL = $_2$ * A $_2$ = 30 * 15 = 450 housing units.
- The number of inhabitants N $_p$ = N $_L$ * D = 450 * 7 = 3150 inhabitants.

Drinking water flow :$Q_{moy\ Aep} = \frac{N_p * d}{86400} = \frac{200*3150}{86400} = 7.291\ l/s$

The average wastewater flow: $Q_{moy\ eu} = 80\ \%\ Q_{moy\ Aep} = \frac{80}{100} * 7.291 = 5.83\quad l/s$

- Peak wastewater flow: $Q_{p\ eu} = k_p Q_{moy\ eu}$

$$k_p = 1.5 + \frac{2.5}{\sqrt{Q_{moy\ eu}}} = 1.5 + \frac{2.5}{\sqrt{5.83}} = 2.53$$

$$Q_{p\ eu} = 2.53 * 5.83 = 14.781\quad l/s$$

The flow to be evacuated is:

$$Q_t = Q_{pS1} + Q_{ps2} = 18.62 + 14.78 = \mathbf{33.40}\ \frac{\boldsymbol{l}}{\boldsymbol{s}}.$$

CHAPTER IV HYDRAULIC CALCULATION OF THE WASTEWATER AND RAINWATER EVACUATION NETWORK

Introduction

The proper functioning of a network is based on a well-controlled calculation; oversizing of structures must be avoided, as it causes premature investments with risks of poor operating conditions during intermediate periods.

The choice of structure sections will result from the application of hydraulic flow formulas. [9]

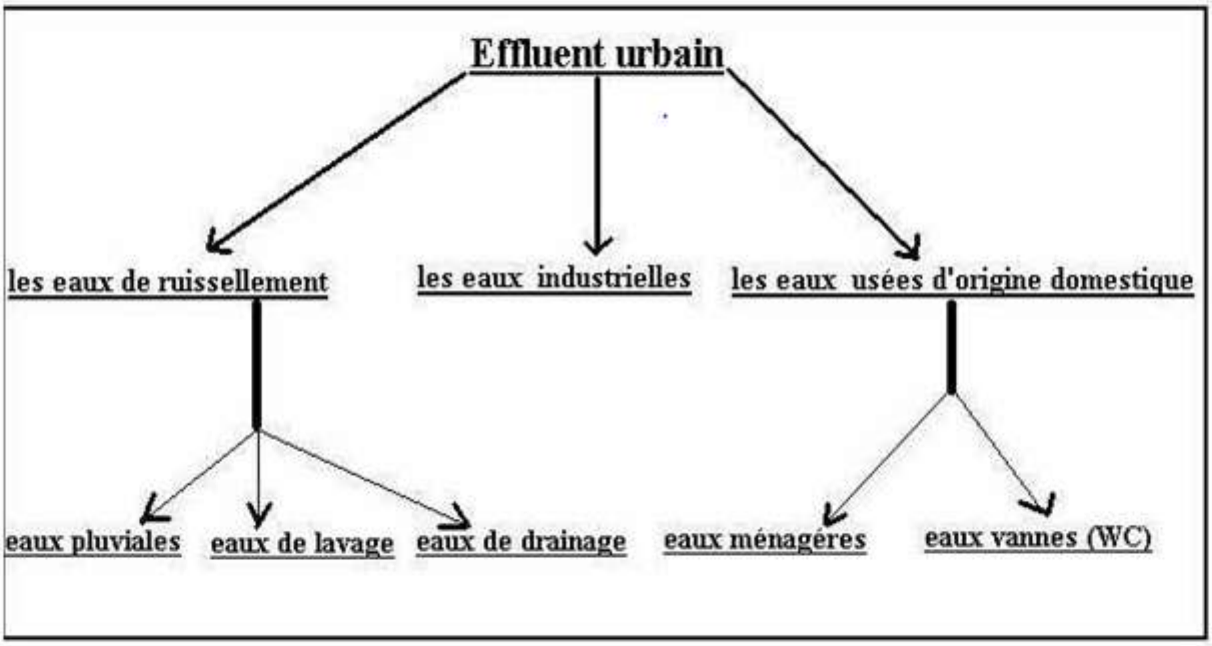


Fig. IV.01 general sanitation plan.

IV.1 Wastewater transport condition

When designing a sanitation network it is necessary to satisfy free surface gravity flow and ensure certain conditions, namely:

IV.1.1 Speed

The speed of wastewater in the networks is limited above and below because it is necessary:

- On the one hand, avoid stagnation likely to cause deposits and carry sediments, otherwise there is a risk of obstruction of the pipes and the release of bad odors due to the decomposition of organic matter.
- On the other hand, prevent erosion of pipes by solid materials carried by water (sand and gravel) or, where applicable, by industrial water. [6]

At low flow rates, a flow speed must be ensured which prevents deposits; the minimum speed to be retained, known as the *self-cleaning speed*, must be:

- In the case of a unitary network, the speed equal to or greater than the sand entrainment speed, i.e. 0.6 m/s, this condition is achieved for an evacuation flow rate equal to 1/10 of the full section flow rate Qps.
- Separative network where we do not benefit from rain flushes, the speed must be of the order of 0.3 m/s but ensuring a filling of 2/10 D

At very high flow rates, and in order to prevent deterioration of the joints of non-visitable structures, the water speed must not exceed 4 m/s

IV.1.2. The slope (implantation conditions)

Self-cleaning conditions are often difficult to achieve in the upstream part where flow rates are low. We then have to look for slopes (0.004 – 0.005), downstream we can accept minimum slopes (0.003 – 0.002).

IV.1.3. The diameters

The minimum diameter is 300 mm in the case of unitary networks, while it is 200 mm in the case of separative networks.

IV.1.4 Ventilation

The need to transport domestic effluent requires that sewers be ventilated structures. This ventilation limits fermentations, the absence of O_2 in the pipes causes the formation of hydrogen sulphide and methane which decomposes and leads to corrosion of the concrete walls of the sewers.

IV.2 Method for calculating a sanitation network

Knowing at each point the flow rates to be evacuated and the slope of the structures, the choice of sections will be deduced from the flow formula adopted. The flow in sewerage networks takes place on a free surface; therefore the flow conveyed by the pipes is given by the continuity equation. [8]

$$\mathbf{Q = V\,S} \qquad \textbf{(IV.01)}$$

With:

Q: conveyed flow m^3/s

V: flow speed m/s

S: wetted section m^2

To calculate the flow speed we use the formula:

IV.2.1 CHEZY formula

The formula for the flow speed given by CHEZY is:

$$\mathbf{V = C\sqrt{R\,I}} \qquad \textbf{(IV.02)}$$

With:

V: Flow speed in m/s

R: Hydraulic radius with R = S/P

S: wetted section in m²

P: wetted perimeter in m

I: Slope of the structure in m/m

C: CHEZY coefficient we adopt that given by the BAZIN formula

$$C = \frac{87}{1+\frac{\gamma}{\sqrt{R}}} = \frac{87\sqrt{R}}{\gamma+\sqrt{R}} \qquad \textbf{(IV.03)}$$

γ : is a flow coefficient which varies depending on the materials used and the nature of the water transported

γ = 0.25 in the case of pipes transporting wastewater

γ = 0.46 in the case of pipes which transport rainwater.

IV.2.2 Manning Strikler formula

$$\mathbf{V = K\,R^{2/3}\sqrt{I}} \qquad \textbf{(IV.04)}$$

With:

K = Manning – Strickler coefficient depends on the roughness of the pipes

K = (20 – 102).

Manning – Strickler proposed the relation for the coefficient of CHEZY: $C = KR^{1/6}$

IV.3 Calculation of a wastewater separative network

A greasy film forms in the structures which improves flow conditions. Also, the Bazin coefficient γ can be taken equal to **0.25** . C can therefore be represented approximately by the expression $C=70.R^{1/6}$.

Speed: $\boldsymbol{V = 70\,R^{2/3}\sqrt{I}}$

The flow : $\boldsymbol{Q = 70\,R^{2/3}\sqrt{I}\;\,S}$

IV.4 Calculation of a rainwater separative network

It should be taken into account that deposits are likely to form, which leads to admitting flow on semi-rough walls.

The Bazin coefficient γ can be taken as **0.46.** C can therefore be represented approximately by the expression $C=60.R^{1/4}$

Speed :$\boldsymbol{V = 60\,R^{3/4}\sqrt{I}}$

The flow :$\boldsymbol{Q = 60\,R^{3/4}\sqrt{I}\;\,S}$

IV.5 Calculation of a unitary network

The calculation will be carried out as for the rainwater network in a separate system given the relative importance of the flow of wastewater compared to that of rainwater.

The hydraulic calculation of sewerage networks is based on the use of several charts which are established by the formulas of MANNING STRICKLER or BAZIN ***Abaque 4a and Abaque 5a.***

All the results obtained are summarized in the table containing the following columns:

1. Number of the basin considered.
2. Section number.
3. Partial area (ha).
4. Cumulative surface area (ha).
5. Specific wastewater flow (l/s/ha).
6. Wastewater flow (l/s/ha) **(6) = (5)*(4)**
7. Partial flow time (min).
8. Cumulative flow time (min).
9. Rainfall intensity (l/s/ha).
10. Runoff coefficient C.
11. Rainwater flow **(11) = (10) * (9) * (4)**
12. Total flow to be evacuated **(12) = (6) + (11)**
13. The length of the section (m).
14. Level of the natural terrain upstream.
15. Level of the natural terrain downstream.
16. Project dimension (invert dimension) upstream.
17. Downstream project rating.
18. Slope of the raft$(\mathbf{18}) = \frac{(\mathbf{17}) - (\mathbf{16})}{(\mathbf{13})}$
19. Diameter in (mm) from the chart **(4a)** according to columns (12) and (18). (See Appendix).
20. Full section speed (m/s) obtained from chart **(4a)** (see appendix), according to columns (19) and (18).
21. Flow at full section (m^3/s)$\boldsymbol{Q_{ps} = V_{ps}\, S}$
22. Flow ratio (rQ)$(\mathbf{22}) = \frac{\mathbf{12}}{\mathbf{21}} \quad \boldsymbol{rQ = \frac{Q_t}{Q_{ps}}}$
23. Ratio of heights (rH) deduced from the chart **(5a).**
24. The filling height (m) **24 = (19) * (23)H = D * rH**
25. Speed ratio (rV). Deduced from the chart **(5a). (See Appendix).**

26. Flow velocity Ve **(26) = (25) * (20)**
27. Self-cleaning speed (m/s) **Ve = 0.6 Vps**
28. Observation.

Application

Calculation of a rainwater separation network:

Check the dimensions of the rainwater drainage network and check the self-cleaning speeds.

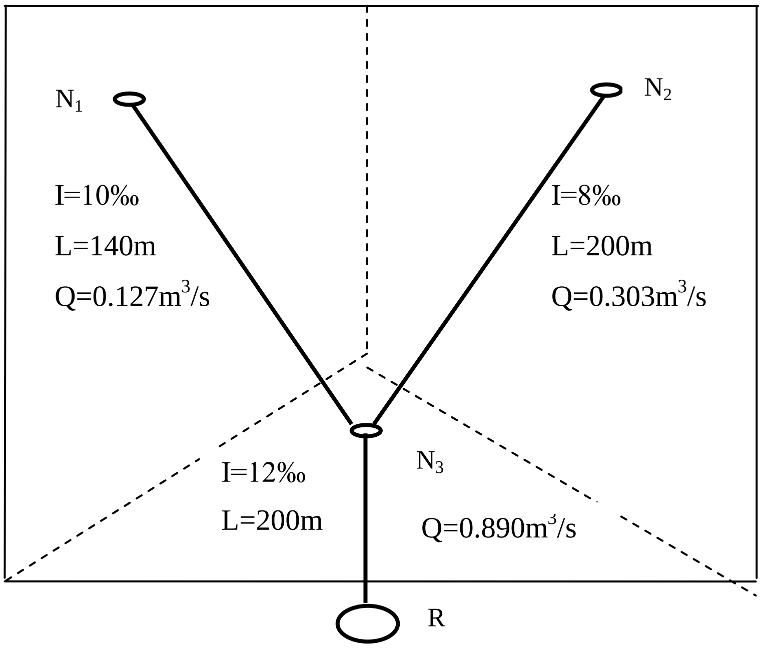


Fig IV.02. Rainwater separative network.

Table IV.01 hydraulic calculation of the rainwater separation network.

Section	Q (m^3/s)	Slop	Φ (m) Abacus 4a	V_{ps} = 60R$^{3/4}$√I with (R=D/4)	Q_{ps}= S Vps * S= (π D^2 /4)	r_{Q}= Q/Qps	r_v Abacus 5a	rH Abacus 5a	Real speed V_r = r_v*V_{ps}	H=r_H *D (m)	Self-cleaning speed =0.6* Vps (m^2/s)
$N_1 - N_2$	0.127	0.01	0.400	1,067	0.134	0.948	0.76	1.13	0.81	0.452	0.486

$N_2 - N_3$	0.303	0.008	0.600	1,293	0.365	0.830	0.68	1.11	0.88	0.67	0.53
$N_3 - R$	0.890	0.012	0.800	1,965	0.988	0.901	0.73	1.12	1.43	0.9	0.86

<u>Calculation of a unitary network</u>

Study the sanitation network of a city if the flow rate of domestic wastewater is 78.31 l/s and the characteristics of the network in the following table:

Table IV.02 Characteristics of the unitary network.

Basin	**Section**	**Length (m)**	**Area (ha)**	**VS**	**i intensity of rain (l/s/ha)**	**I (‰)**
	1 – 2	160	1.92			
	2 – 3	160	1.92			
	3 – 4	160	1.92			
	4 – 5	160	1.92			
A	5 – 6	160	1.92	0.5		5.12
	6 – 7	140	1.68			
	7 – 8	130	1.09			
	1 – 2	180	2.6		40	
	2 – 3	120	3.87			
B	3 – 4	120	1.56	0.7		5
	4 – 8	120	1.30			
C	8 – R	300	3.00	0.7		17

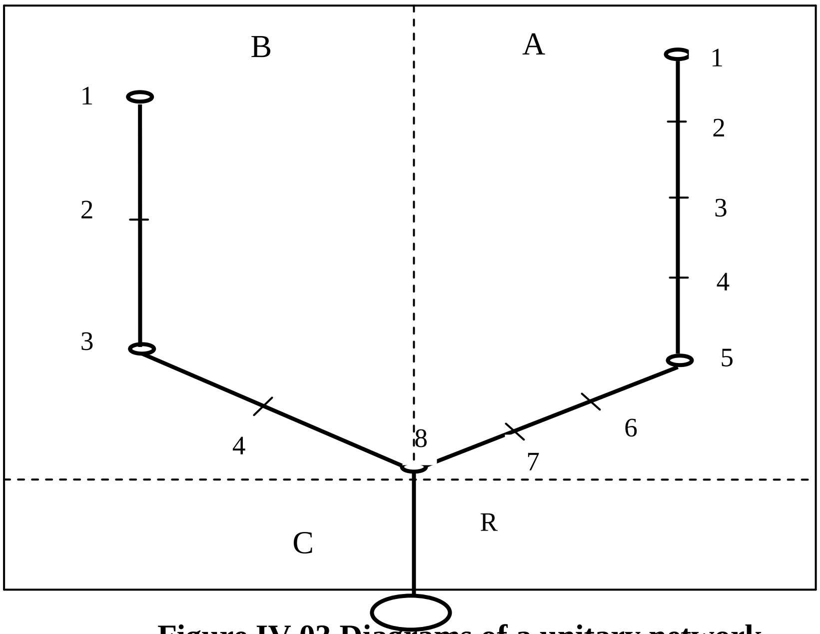


Figure IV.03 Diagrams of a unitary network.

The flow of rainwater is calculated by the rational formula $Q = k\ C\ i\ A$

We take k = 1

<u>Calculated the specific flow:</u>

The specific flow rate is calculated by the following formula:

$$q_{sp} = \frac{Q_{eu}}{\sum L} = \frac{78.31}{1910} = 0.041 q_{sp} = 0.041 \text{ l/s/ml}$$

The calculation results are presented in the table below: (Table IV.3).

Table IV.03 Hydraulic calculation of the unitary network

Basin	Section	length (m)		Specific flow (l/s/ml)	Wastewater flow (l/s)	Area (ha)		i intensity of rain (l/s/ha)
		partial	cumulativ			Partial	cumulativ	
A	1 – 2	160	160	0.041	6.56	1.92	1.92	
	2 – 3	160	320		13.12	1.92	3.84	
	3 – 4	160	480		19.68	1.92	5.76	
	4 – 5	160	640		26.24	1.92	7.68	
	5 – 6	160	800		32.8	1.92	9.6	
	6 – 7	140	940		38.54	1.68	11.28	

	7 – 8	130	1070		43.87	1.09	12.37	40
B	1 – 2	180	180		7.38	2.6	2.6	
	2 – 3	120	300		12.3	3.87	6.47	
	3 – 4	120	420		17.22	1.56	8.03	
	4 – 8	120	540		22.14	1.30	9.33	
C	8 – R	300	1910		78.31	3.00	24.7	

C	Rainwater flow	Total flow (l/s)	Total flow (m^3/s)	I (‰)	Diameter (m)	$V_{ps} = 60R^{3/4}\sqrt{I}$ with (R=D/4)	$Q_{ps} = V_{ps} * (\pi D^2/4)$
0.5	38.4	44.96	0.04496	0.00512	0.400	0.763	0.0958
	76.8	89.92	0.08992		0.400	0.763	0.0958
	115.2	134.88	0.13488		0.500	0.902	0.177
	153.6	179.84	0.17984		0.600	1.034	0.292
	192	224.8	0.2248		0.600	1.034	0.292
	225.6	264.14	0.26414		0.600	1.034	0.292
	247.4	291.127	0.291127		0.800	1,284	0.645
0.7	72.8	80.18	0.08018	0.005	0.400	0.754	0.095
	181.16	193.46	0.19346		0.600	1.02	0.288
	224.84	241.06	0.24106		0.600	1.02	0.288
	261.24	283.38	0.28338		0.800	1,268	0637
0.7	691.6	769.91	0.76991	0.017	0.800	2.34	1.175

$r_{Q=Q/Qps}$	r_v	rH	Real speed	$H = r_H * D$	Self-cleaning	

	Abacus 5a	Abacus 5a	$V_r = r_v * V_{ps}$ (m^2/s)	(m)	speed $=0.6* V_{ps}$ (m^2/s)	observation
0.469	0.985	0.47	0.751	0.188	0.457	< 0.6
0.939	1.13	0.75	0.862	0.300	0.457	< 0.6
0.762	1.10	0.65	0.992	0.325	0.541	< 0.6
0.615	1.05	0.55	1,085	0.330	0.620	
0.769	1.1	0.65	1.137	0.390	0.620	
0.904	1.13	0.73	1.168	0.438	0.620	
0.997	1.13	0.79	1,450	0.632	0.770	
0.844	1.11	0.69	0.837	0.276	0.452	< 0.6
0.671	1.07	0.59	1.091	0.354	0.612	
0.837	1.11	0.68	1.132	0.408	0.612	
0.983	1.125	0.78	1,426	0.624	0.760	
0.655	1,065	0.58	2,492	0.464	1.404	

For the sections (1–2) (2–3) (3–4) of the basin (A) and the section (1–2) of the basin (B) with the diameters and the slopes proposed the condition of the speed of self-cleaning is not verified. If we accept the result of the hydraulic calculation in these sections, there may be problems later in the network, regarding the proper functioning of these sections. We can give the following suggestions to avoid these problems:

1. Change the slope of the pipe and redo the calculation with the new slope.
2. Do not change the characteristics of these sections but introduce a specific management system for these sections

- Periodic cleaning of the manholes in these sections.
- Remove sediment surrounding the surface of the sections.
  - Periodic hydrocleaning, which allows cleaning or unblocking under water pressure.

CHAPTER V: MAIN WORKS OF THE SANITATION NETWORK

Introduction

The main works of a sewerage network include a variety of structures and equipment designed to collect, transport, treat and evacuate wastewater and stormwater. Here is a list of the main works: [6]

V.1 Conditions for choosing sanitation pipes

V.1.1 Technical criteria

- Flow of waste and rainwater: Diameter and material adapted to the flow to avoid overloads or stagnation.

- Soil characteristics: Sandy or loamy soil requires PVC or PE pipes; Clay or rocky soil requires cast iron or concrete.

- Topography of the land: Route adapted to the relief to avoid stagnation, possibly with inspection manholes or lifting stations.

- Burial depth: Protection against surface loads and bad weather, taking into account other underground networks.

V.1.2 Environmental criteria

- Impact on the environment: Durable and recyclable materials, non-polluting installation techniques.

- Noise: Reduction of noise generated by the passage of water.

V.1.3 Economic criteria

- Cost of materials and installation: Balance between technical performance, environmental requirements and economic constraints.
- Maintenance and upkeep: Ease of access and maintenance of pipes.

V.1.4 Specific conditions

- Wastewater pipes: Resistance to corrosion and chemicals, materials that do not release harmful substances.
- Rainwater pipes: Materials resistant to bad weather and temperature variations.
- Pressure pipes: Resistance to high pressures, safety and durability guaranteed.

V.2 Types of pipes

There are several types of pipes which are different depending on their material and their destination:

V.2.1 Reinforced concrete pipes

Reinforced concrete pipes are manufactured mechanically by a process ensuring high compactness of the concrete (radial compression, vibration, and centrifugation). The pipes have two series of reinforcements, the first is formed of straight bars called generators, and the second is formed of continuous helical turns with a maximum regular pitch of 1.5 m. The useful length must not be greater than 2 m [11] (figure V.01).

Fig. V.01.Conducts of concrete armed.

V. 2.2 Unreinforced concrete pipes

Unreinforced concrete pipes are manufactured mechanically by a process ensuring high compactness of the concrete. The useful length must not exceed 2.50 m. These types of pipes have a sudden break, but unless the cover height is insufficient. It occurs in the early stages of the pipeline. It is not recommended to use unreinforced pipes for inspectable pipes. (Figure V.02).

Fig. V.02.Conducts of concrete no armed.

V.2.3 Asbestos – cement pipes

Asbestos-cement pipes and fittings consist of a mixture of Portland cement and asbestos fiber made in the presence of water. This type is manufactured in two types depending on the method of assembly; interlocking or non-interlocking with two smooth ends. Diameters vary from 60 to 500 (mm) for lengths varying from 4 to 5 (m). (Figure V.03).

The assembly of this pipe is done by a rolling joint for pipes with a socket with a diameter varying between 100 and 600 (mm), it is also done by a sliding joint for pipes without a socket with diameters varying between 700 and 800 (mm). mm). [11]

These pipes resist electrochemical corrosion well, but the disadvantage lies in their non-availability on the market for large diameters.

Fig. V.03. Pipelines in asbestos cement

V.2.4 Sandstone pipes

The sandstone used for the manufacture of pipes is obtained from equal parts of clay containing silica, alumina and clay sand fired between 1200°C to 1300°C. (Figure V.04).

The resulting material is very waterproof. It is unassailable to chemical agents, except hydrofluoric acid. The use of this kind is recommended in industrial areas. There minimum length is 1(m) Disadvantage It is that he wrong resist to settlements. [10]

Assembly se do by :

- Seal with mortar of cement.
- Seal with tarred rope and mortar of cement.
- Seal doubled rings.

Fig. V.04. Pipelines in sandstone.

V.2.5 Unplasticized polyvinyl chloride (PVC) pipes

These pipes are sensitive to the effect of temperature below 0° C. They have a certain sensitivity to shock. The influence of expansion is especially important and must be taken into account at the time of installation. The minimum length is 6(m). (Figure V.05).

Fig. V.05. Pipelines in PVC.

V.3 Pipe form

Pipelines can be manufactured in various geometric shapes, each offering specific advantages depending on the conditions of use and technical requirements. Here is an overview of the different forms of pipes used in sanitation networks [09]:

V.3.1 Circular pipe

Circular pipes are a wise choice for sewerage systems due to their many advantages, including their strength, hydraulic efficiency, ease of manufacture, installation and maintenance, durability, versatility, adaptability, their respect for the environment, their cost-effectiveness, their compliance with standards and regulations and their availability.

Fig. V.06. Diagram: circular pipe

V.3.2 Oval or ovoid pipes

Ovoid, or egg-shaped, pipes are mainly used in unitary networks where the transport capacity must adapt to significant variations in flow:

1. Ellipse shape, wider than tall.
2. Allows flow to be optimized for high flow rates.
3. Typical diameters: up to 2400 mm.
4. Used for large collectors. (figure V.07)

Fig. V.07. Diagram: ovoid pipes.

V.3.3 Rectangular pipes

Rectangular pipes are often used in main collector sewers and large capacity underground drainage lines. (Figure V.08)

1. Square or rectangular section shape.
2. Allows adaptation to restricted spaces.
3. Used for high flow rates in urban areas.
4. Materials: reinforced concrete, steel.

Fig. V.08. Diagram: rectangular pipes.

V.3. 4 Arched or vaulted pipes

These forms of pipes, such as arches or vaults, are often used to cross obstacles such as roads, railways or waterways. [09]

1. Arc or semi-circle shape.
2. Provide good mechanical resistance.
3. Used for great burial depths.
4. Typical diameters: up to 6000 mm.

The choice of shape depends on the flow rates to be transported, the space constraints and the installation conditions in the field. (Figure V.09).

Fig. V.09. Diagram: arched or vaulted pipes

V.4 Nature of pipes

The choice of materials depends on:

- The nature of the base area
- The chemical nature of the fluid to be evacuated
- Its availability on the market and the cost
- Resistance under the effect of external loads
- Of the slopes of ground;
- Of the diameters used;

CHAPTER VI: ANCILLARY WORKS OF A SANITATION NETWORK

Introduction

The ancillary works of a sanitation network are essential elements which complement the main pipes and collection works to ensure the proper functioning of the sanitation system. They allow you to access the network, monitor it, regulate it, protect it and process it. We generally distinguish the following ancillary works: [08]

VI.1 The elements of a sanitation network

VI.1.1 looks

These are reinforced concrete structures, they are watered on the ground equipped with a frame and a buffer, designed to resist the thrust of the earth and that generated by the passage of rolling loads. [10]

VI.1.1.1 Inspection port

- Role

The role of the inspection manholes is to allow access to the pipes for cleaning; in addition, they provide ventilation of the sewers. (Figure VI.1).

- Spacing

The installation of inspection ports will be recommended on the collectors in the following cases:

• At each junction between two collectors;

• At each change of direction;

• At each change of section;

• At each change in slope;

• Every 40 to 50 meters for pipes with a diameter of less than 1,000 mm;

• Every 80 to 120 meters for pipes with a diameter greater than 1,000 mm.

Fig. VI.01. Inspection manhole diagram.

They are installed at:

- Each change of direction
- Each change in diameter
- Distance between two successive manholes is 30 to 50 m, except in special cases.

VI.1.1.2 Falling manholes

This type of manhole is very necessary in the case of very uneven terrain; their role is to reduce steep slopes. (Figure V.2).

A drop manhole is installed when the invert of the pipe which carries the water is located more than 600 mm from the crown of the pipe which evacuates it. [09]

They are generally used for two different types of falls:

- ✓ **The vertical drop:** deep Used for a small diameter and a high flow rate; their goal is to reduce speed.
- ✓ **The slide chute:** This chute is used for fairly large diameters, it ensures continuity of flow and helps avoid swirl.

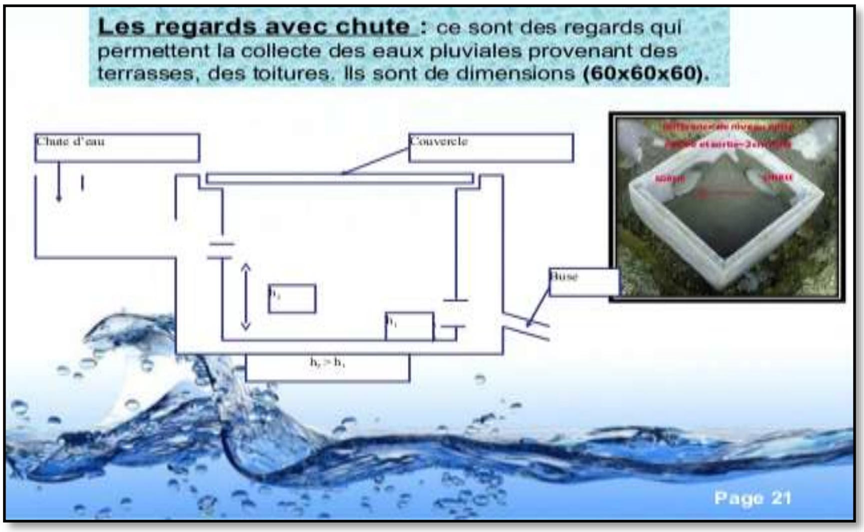


Fig. VI.02. Diagram: fall look.

VI.1.1.3 Hunting gaze

This type of manhole is installed at the head of the network to compensate for waste, if the self-cleaning conditions are not verified. [11]

VI.1.1.4 the outlet

This is the last work delivered by the projector on plan.

VI.1.1.5 Connection sight

It allows the connection between the sanitary network of buildings and the external sanitation network.

(See Figure VI.3).

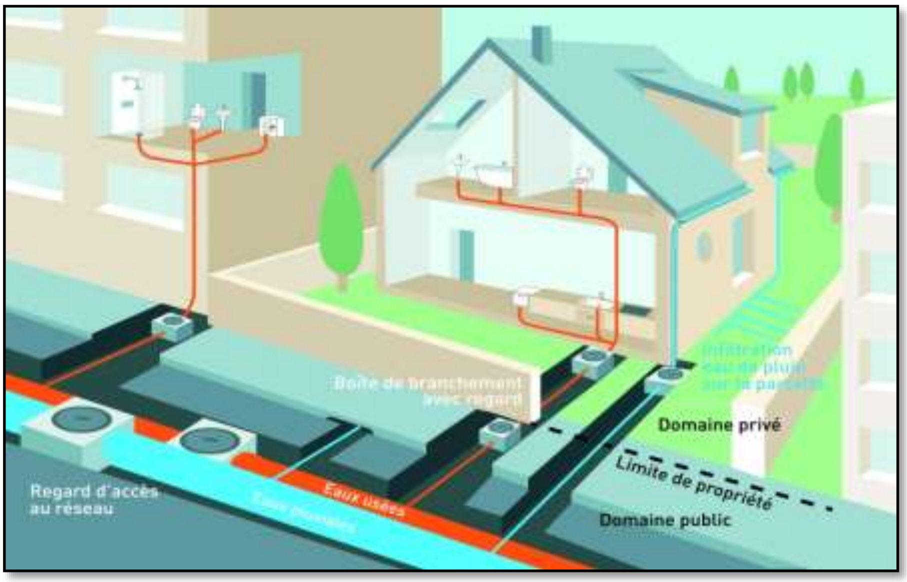


Fig. VI.03. Connection manhole diagram.

VI.1.1.6- Sump manhole (manhole)

These are ancillary structures intended to collect surface runoff water (from rain, washing of roads, parking lots, sidewalks, etc.) and to convey it to the sewer via a pipe; it is essential to clean it after each storm. [06]

A manhole cover is an element specific to rainwater networks and combined networks. The function of a manhole is to collect rainwater from roads and sidewalks. (See Figure VI.4).

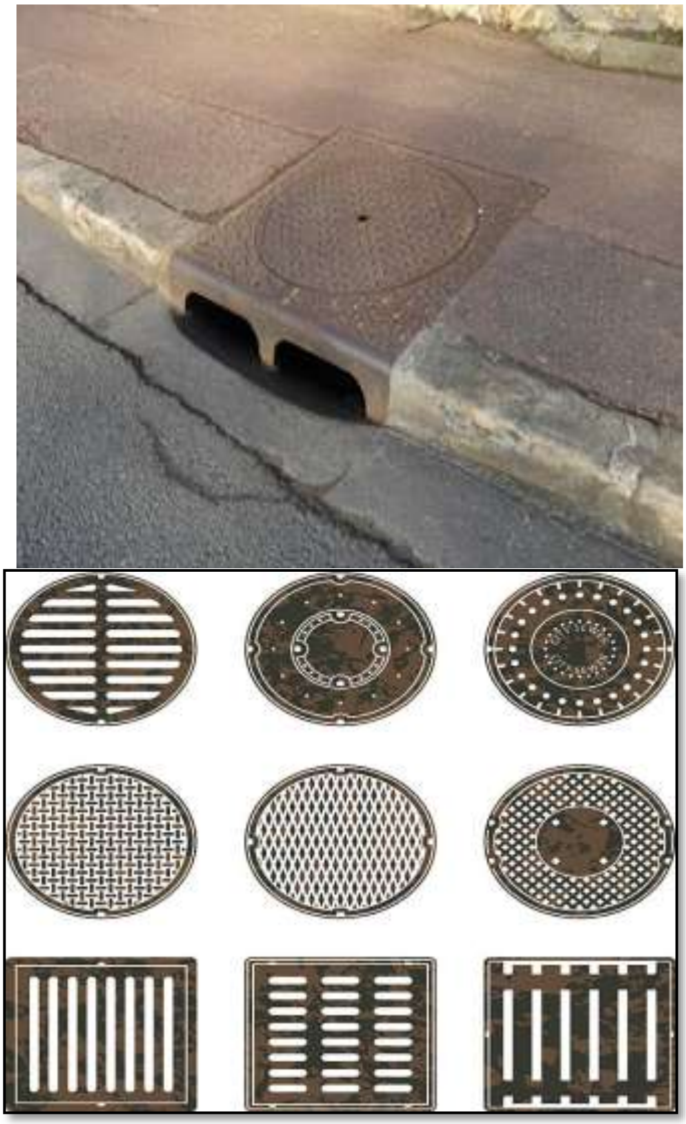


Fig.VI.04. Sinkhole diagram.

VI.1.1.6.1 Type of manhole covers (manholes)

There are several types:

<u>-Manholes with a circular section of 0.5m in diameter with or without decantation:</u> This type of manhole can be adapted especially if the network risks not being subject to permanent maintenance. Depending on the type of water collection, there are five types of manhole cover.

-Manholes with grate and metal coping: These outlets can be selective or not. When decantation is planned, the water enters the network either by means of a siphon, or directly by pouring above the threshold of the decantation sump.

-Manholes with stone or concrete flap and metal coping: They can be selective or not, with or without siphoid decantation or not. In the latter case the funnel is extended by a skirt whose base must plunge at least 0.05 m below the permanent level of the settling sump.

-Manholes with flap and stone or concrete coping: This type is a variant applicable to the two previous types.

-Manholes with metal drain: They are like the previous ones, the only particularity lies in the fact that the upper metal device fits directly onto the upper level of the chimney.

- The grate-only manhole cover: The grate-only manhole covers fit directly onto the upper level of the chimney.

VI.1.1.7- Junction manholes

Intended to avoid the right angle connection of a lateral pipe to promote flow while reducing pressure losses. They are used to unite two collectors of the same or different sections; they are constructed in such a way as to know [09]:

- ✓ Good ventilation of the collectors at the junction (manhole);
- ✓ The differences in height between the collector inverts;
- ✓ An absence of water reflux in dry weather;
- ✓ The water levels in the pipes must be at the same height.

VI.1.1.8 -Ventilation manhole

The presence of air in the sewers is the best guarantee against fermentation producing gaseous hydraulic sulphide; ventilation is carried out by **[** 11] :

- ✓ The manhole covers fitted with appropriate orifices;
- ✓ Drop pipes which must be extended to the open air;
- ✓ The chimneys placed on the axis of the pipe.

VI.1.2 Lift stations

In principle, we try, whenever it is possible to achieve gravity flow in a sewer network, because lifting stations increase the costs of the installations and they are difficult to maintain. (Figure VI.05).

In any case, they are generally only provided for wastewater networks, the collection of rainwater posing difficulties due to the variation and the importance of the flow rates.

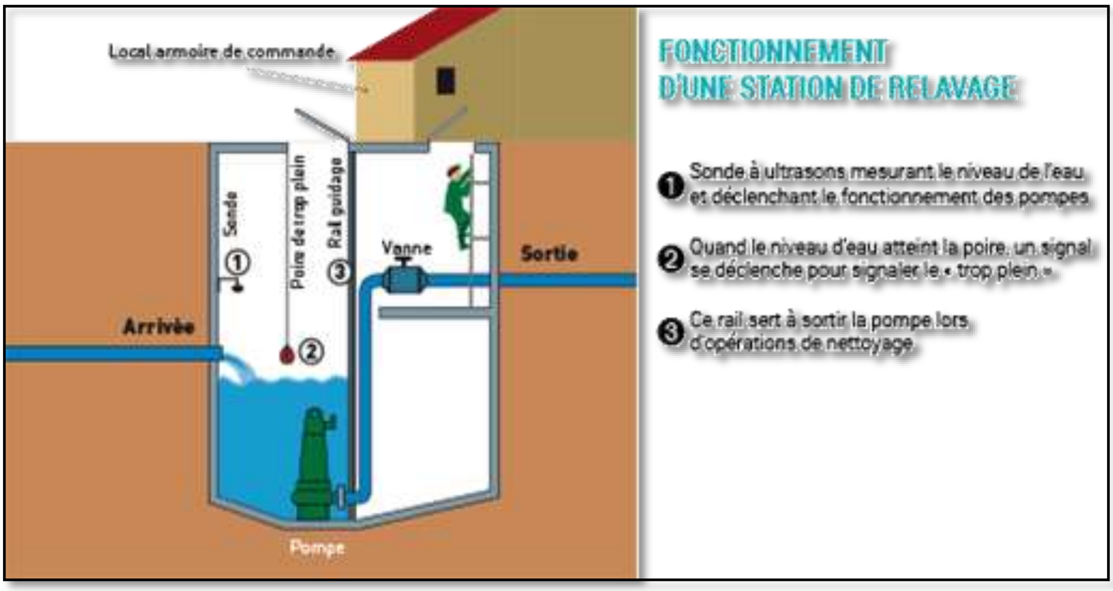


Fig. VI.05 lifting station. [11]

VI.1.3 storm overflows

These structures are intended to relieve excess flow in rainy weather by allowing relief of the downstream network. The surplus is evacuated directly into the natural environment.

These structures are often installed at the entrance to wwtps, on interception sections and on certain pipes considered overloaded. They thus make it possible to reduce the large dimensions of the pipes and the cost of the project. (Figure VI.06).

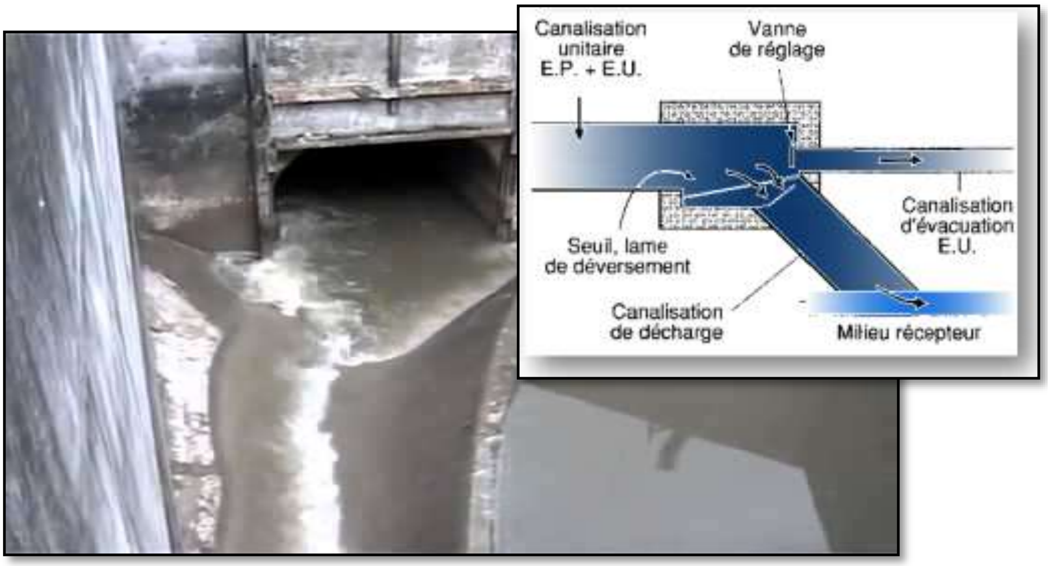


Fig. VI.06. Storm spillways [07]

VI.1.3.1-Location of storm spillways

Before the location of the storm overflows it is necessary to see:

- ❖ The receiving environment and its balance after the discharge of the effluents, a degree of dilution of which must be established according to the self-purifying power of the receiving environment.
- ❖ The flow values compatible with the dilution value and with the general economy of the project, that is to say seek the discharge probability factor so as to limit the frequency of effluent releases into the receiving environment.
- ❖ The capacity and surface areas of the treatment plant works to avoid overloads and poor operation.
- ❖ The water level flow regime in the upstream and downstream pipeline.
- ❖ Site topography and slope variations.

VI.1.3.2-type of spillways

There are several types of spillway [05]:

VI.1.3.2.1 -Weir with lateral threshold and restricted downstream pipe: For the calculation of this work, the upstream flow must be fluvial. The presence of a high threshold (safety margin) leads to the formation of a jump in the supply pipe. The valves used on the discharge pipes can be manipulated depending on the flow rate passed through the spillway.

VI.1.3.2.2 -Weir with lateral sill and free downstream pipe: This type of weir differs from the previous one essentially in that the downstream pipe has a free flow, if for the max flow. storm load on the downstream crest is zero. This type of weir will ensure a constant downstream flow regardless of the flow discharged.

VI.1.3.2.3-Storm overflow with bottom opening: In this type of structure, the flow of wastewater passes through an opening made in the base of the pipe.

We have other types of spillways such as :

- ✓ Frontal weirs;
- ✓ Siphoid weirs;
- ✓ Automatic weirs.

Calculation of the length of the weir threshold [09]

Here is how to calculate the length of the threshold of a spillway:

The length of the overflow threshold (L) is an important parameter for sizing a spillway. It is included in the general formula for weir flow:

$$Q_{dév} = m \times L \times \sqrt{2g} \times H^{\frac{3}{2}} \qquad \textbf{(IV.01)}$$

Or:

- Q is the flow rate to be evacuated (m³/s)
- µ is the flow coefficient of the weir (without unit)
- L is the length of the overflow threshold (m)
- g is the acceleration of gravity (9.81 m/s²)
- h is the height of the overhanging blade (m)

To calculate L, we can rewrite this formula as a function of L:

$$\mathbf{L} = \frac{Q}{\mu\sqrt{2gh^{\frac{2}{3}}}} \qquad \textbf{(IV.02)}$$

The flow rate Q and the height h are generally known. It is then necessary to choose a value for the coefficient µ depending on the type of weir:

- For a thin-walled rectangular weir without lateral contraction, µ ≈ 0.40
- For a triangular weir, µ ≈ 0.58 for a top angle of 90°
- For a trapezoidal weir, µ is between 0.40 and 0.45

VI.1.3.3-Pumping station (sewage lifting station)

Pumping stations are intended for sanitation, to raise water from one level to another, either to overcome an obstacle, or to modify routes that have become economically unacceptable in a gravity network, or due to conditions incompatible with the downstream data. (Figure VI.07).

A pumping station is made up of:

- ✓ A temporary storage or effluent recovery tank, normally equipped upstream with a screen and a sand removal chamber, which is desirable to limit abrasive effects and ensure the durability of hydroelectric equipment;
- ✓ A hydroelectric unit made up of one or more motor pumps, submerged or not, pipes and equipment necessary for effluent drainage.

Fig. VI.07: Pumping station. [11]

VI.1.4 retention basins

The retention basins are located upstream of the WWTPs and flood zones. They make it possible to limit peak flows by limiting storm inputs into public networks and protect the natural environment. [10]

These structures are imposed by the topographical conditions of the site and the rainfall data of the region.

The retention basins are essentially made up of:

- ✓ A basin body (bottom and bank).
- ✓ A downstream structure, generally consisting of a dike with a water evacuation device.

Retention basins have the disadvantage of temporarily occupying large spaces, often within the urban fabric, intended for parks and green spaces; they should therefore be avoided whenever possible. (Figure VI.08).

Fig. VI.08.retention basin. [10]

The main works include:

• Circular pipes

• Prefabricated ovoid pipes

• Visitable works of particular profiles, limited to large urban centers.

VI.1.5. Joints

They constitute the weak points of the network, they must necessarily and imperatively meet the technical requirements:

- Tightness and flexibility
- Resistance to hydraulic pressure and effluent attacks
- be protected from attack by plant roots.

V.1.6 Retaining grids

To avoid the intrusion of elements likely to disrupt the flow; it is advisable to place the grills at the entrance to the storm overflows. [07]

Their role is to retain the largest bodies transported by storm effluents or by wastewater effluents as they flow through the network.

These structures are very effective upstream of desilting basins, storm spillways and lifting stations.

The grids are used to retain coarse materials carried by the water which could harm the effectiveness of the treatment. They consist of grilles with bars placed at an angle in the channel and are made of simple or profiled flat iron or round iron.

To avoid flooding when the grid is blocked by sudden rain or careful handling, each grid is equipped with a by-pass. The flow speed between the bars of the grid must not exceed (0.5 to 1.5) m/s.

The screens can be fixed or mobile, with cleaning installed at shallow depths. There are vertical and inclined grids. The spacing (e) between the bars of the grid depends on the fineness of sieving that we wish to obtain. **(** Figure.VI.09).

In certain installations, clogging of the grids creates a pressure loss which causes the upstream level to rise. [05] [11]

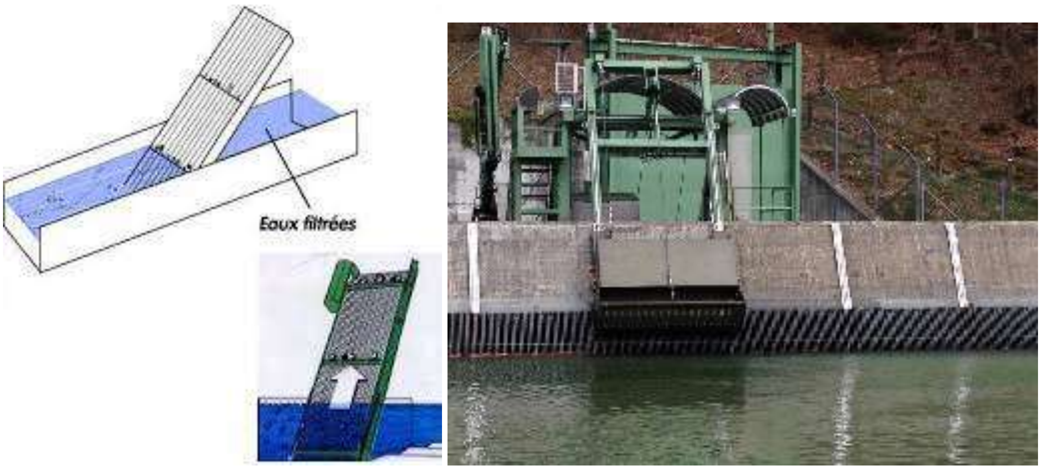


Fig. VI.09. Example of retaining grid. [11]

VI.1.7-Sand traps

These are structures which must be placed downstream of the secondary collectors so as not to let the sand flow into the main collectors, so as not to erode the walls and to avoid fermentation of plant elements.

Grit traps are structures that eliminate easily settleable materials carried by waste and rainwater (most often sand).

The grit collectors are always placed downstream of the grids and upstream of the primary settling tanks in wastewater treatment plants, at the level of the low point siphon; and upstream of storm spillways. [09]

It may nevertheless be necessary to place them on the sanitation network to protect the structures against:

- ✓ Friction on collectors and pumps.
- ✓ Losses in usable volume due to deposits that form quickly.

V.1.7.1-The different types of grit collectors:

Grit traps are always placed downstream of the grids and upstream of the primary settling tanks in wastewater treatment plants, at the level of the low point siphon; and upstream of storm spillways.

- ✓ **Corridor sand trap:** This is a channel with a widened part. The entrance must be constructed in such a way that the speed is reduced with a speed distribution at this enlarged part as regular as possible or a speed of 0.3 m/s can be maintained.

- ✓ **Rectangular sand trap:** these structures make it possible to treat large flow rates of up to 15,000 m^3/h. (see Figure VI.10).

An insufflation system can be installed along the entire length of the structure. The blown air allows separation of organic matter deposited on the sand particles and also allows separation of floating materials. Sand extraction is carried out in several ways: by scraping or by suction pump.

- ✓ **Circular sand trap:** cylindrical-conical in shape, the sweeping speed of the base is kept constant thanks to a tangential supply of water or by mechanical mixing.

The dense particles will be able to stick to the walls of the device by centrifugal effect, and will be collected in the conical bottom of the structure.

- ✓ **Combined grit-degreaser:** desanding and degreasing are carried out in the same basin. These structures make it possible to separate sand, water and fats thanks to the difference in density. [09]

Indeed, the sand will settle in the bottom of the sand trap (most often cylindrical-conical), the fats are floated by the insufflation of air bubbles. The fats are scraped from the surface by a rotating skimmer. These are the most used sand traps.

VI.1.9-Settling basins

Structure installed in a sanitation system, with the aim of creating adequate flow conditions allowing the settling of particles transported by the flow. More precisely, this term can designate different types of structures (Figure V.10).

- ✓ **In wastewater treatment plants:** this may be a treatment tank used for primary treatment (primary settling tank) or a treatment tank used after the aeration tank in activated sludge plants (secondary settling tank). We then rather speak of Clarifier.

- ✓ **On separative networks:** it may be a treatment basin intended for the temporary storage of rainwater, with the aim of decanting it before its discharge into the receiving environment. [10]
- ✓ **On unitary networks:** it may be a device aimed at separating the coarsest materials transported in the flow; we speak of a grit collector.

Fig. VI.10. Example of a settling basin. [10]

VI.2 systematic ancillary works

VI.2.1-Connections

The connection boxes which are in fact mini-manholes, which allow the connection of internal pipes collecting sewage and domestic water with the connection to the network. Likewise, with regard to rainwater fall foot boxes.

These connection boxes also provide control and evacuation access. The one-eyed gaze on the non-visitable collection network which receives a building connection is generally called a connection box. [10]

Previous techniques led to works of all sizes, with fittings in cups, pans, airtight boxes, siphon disconnectors, etc. of all types, most often cast in place, and pointing with cement mortar.

Current techniques aim to standardize these structures and to make greater use of industrialized constituent elements with flexible joints.

VI.2.1.1-A connection includes three essential parts

- A facade inspection window which must be placed along the public road and as close as possible to the facade of the connected property to allow easy access to personnel responsible for operation and monitoring proper functioning.
- Branching pipes which are preferably connected along an oblique angle inclined at 45° where. 60° relative to the general axis of the public network. [05]

- The connection devices of the branch pipe are linked to the nature and dimensions of thepublic network.

Fig. VI.11. Connection box. [05]

VI.2.1 Special connections

VI.2.1.1 facade views

The facade manholes must be placed along the public road as close as possible to the connected property to allow easy access to the personnel responsible for operation. (Figure V.12. facade view).

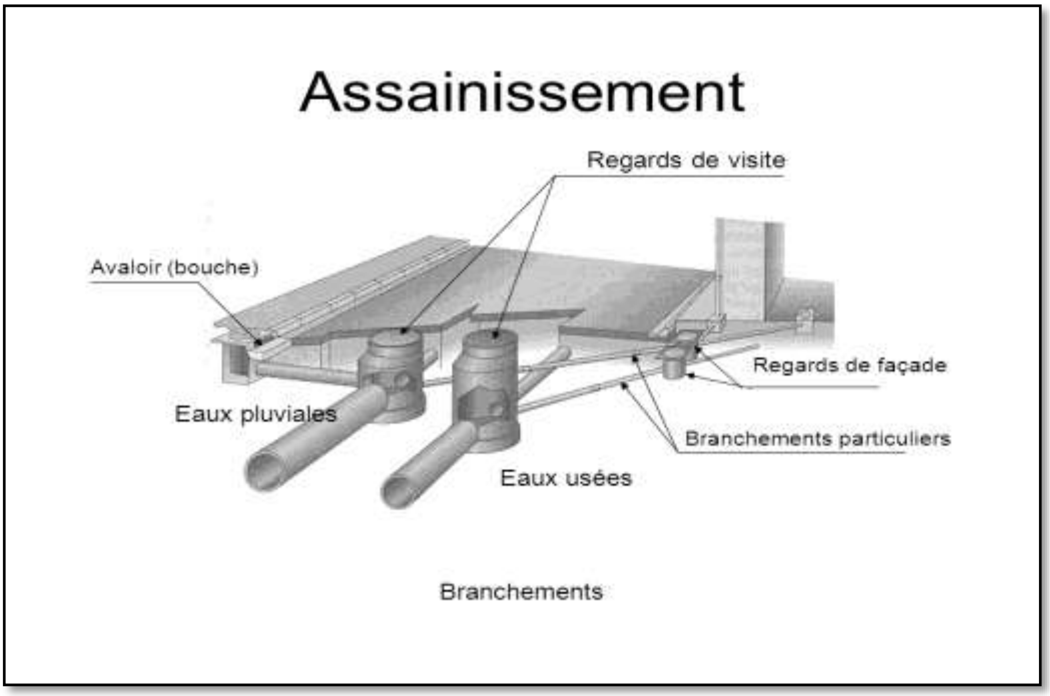


Fig. VI.12. Facade view. [05]

These structures can have square or circular sections whose dimensions vary between 40 and 60 cm. The depth is imposed by the space constraints of the ground and the altimetric requirements of the public network.

Facade manholes intended for industrial water must be designed to allow initial settling, and must be easily accessible in the event of inspection or control.

VI.2.1.2-connection devices

The connection pipes, section 200 or 300 mmdepending on the sanitation system adopted, are connected to the city network by one of the following devices: [11]

- Blind connection box;
- Nozzle connection;
- Tulip connection.

VI.2.1.3- Gutters

The gutters, annexes to the road along the edge of the sidewalk, are intended to receive water from runoff and gutters via gargoyles, and ensure the surface transport of rainwater to the outlets and drains.

Their use is also necessary for breaks in the slopes of paved spaces (parking, etc.); depending on the importance, they can be made up of longitudinal structures equipped with grilles or Saujon type slots, more economical and well suited to urban expressways, the fragility of the grilles, etc. (Figure VI.13). [10]

Fig. VI.13. Gutter installation. [10]

GENERAL CONCLUSION

The course, sanitation, aims to help exploit and enhance the environment, by organizing and transforming it to be able to draw from it the resources we need to solve our various survival problems, such as the problems regarding the evacuation of waste and rainwater and their decontamination.

Good design of sanitation networks allows us to protect the population against natural disasters (floods), protect the environment and increase water potential through the reuse of treated wastewater.

The protection of agglomerations is ensured by correct sizing, by estimating flood flows as well as ensuring self-cleaning conditions.

Sanitation network we can ensure protection of our environment. The construction of special works (storm overflows, settling basins, sand chambers, etc.) reduces the pollutant load, especially suspended matter before arriving at a treatment plant.

In conclusion, the commitment to sanitation is an investment in our collective future. It is a shared responsibility that requires the cooperation of all stakeholders: governments, international organizations, the private sector, and citizens. Together, we can ensure that every person, regardless of where they live, enjoys the benefits of safe and sustainable sanitation.

Bibliographic references

[1] https://www.cieau.com/le-metier-de-leau/ressource-en-eau-eau-potable-eaux-usees/histoire-des-eaux-usees/

[2] Bourrier.R, 2008, Sanitation networks, Edition Lavoisier.

[3] DERNOUNI.F. “Sanitation of urban areas” ENSH 2004.

[4] H.Guerree & C. Gomella, Wastewater in urban or rural areas, La Collection 1.

[5]GOMELLA, C., GUERREE, H., 1986 “Guide to sanitation in urban and rural areas (volume 1), Eyrolles, Paris.

[6] Guerrée.H, Gomella,C, (1978). Wastewater in urban and rural areas, Volume I, Eyrolles, Paris.

[7] The Battle of the Waters: hygiene in Rennes in the 19th century. Rennes: Presses Universitaires de Rennes, 1994. (History). 164 pp.

Available online on Gallica: http://gallica.bnf.fr/ark:/12148/bpt6k3346930h

[8] Marié-Davy, Hippolyte, Sewerage system: special drainage pipes. Paris: French Hygiene Society, 1882. (Publications of the French Hygiene Society). 14 p.

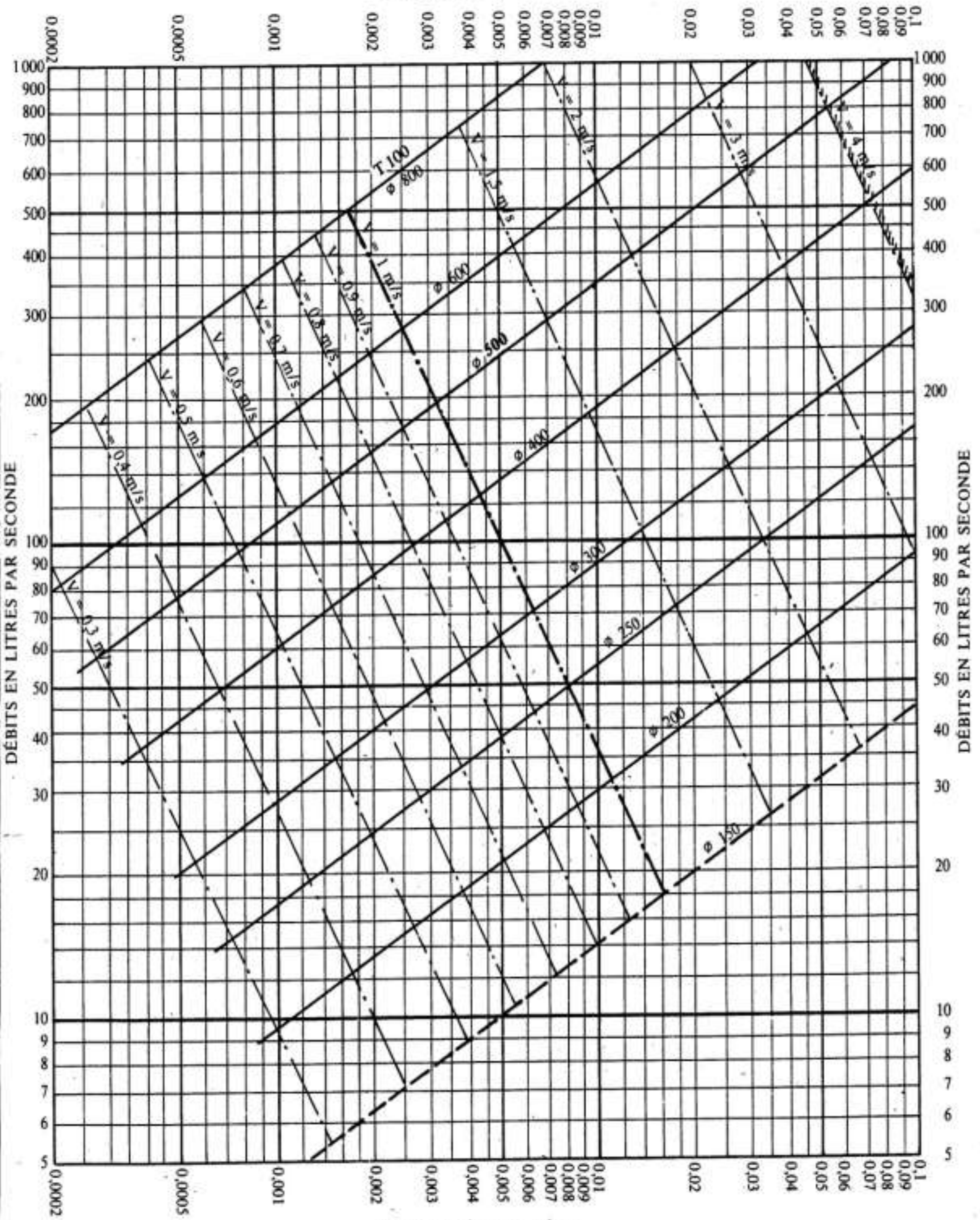
[9] Valentin A, “Sanitation works”, Eyrolles edition, 1972.

[10] Valiron F, "Lyonnaise des Eaux. Memorandum for the Manager of water supply and sanitation. Volume I Water in the city Water Supply. Paris", Technique and documentation Lavoisier, 1994. 435 p.

[11] September 2016, management of wastewater networks, guide to precast concrete solutions DP119 - interior creation: Agence Planète - copyrights: CERIB.

ABAQUE Ab. 3 Ab. 3

RÉSEAUX D'EAUX USÉES EN SYSTÈME SÉPARATIF



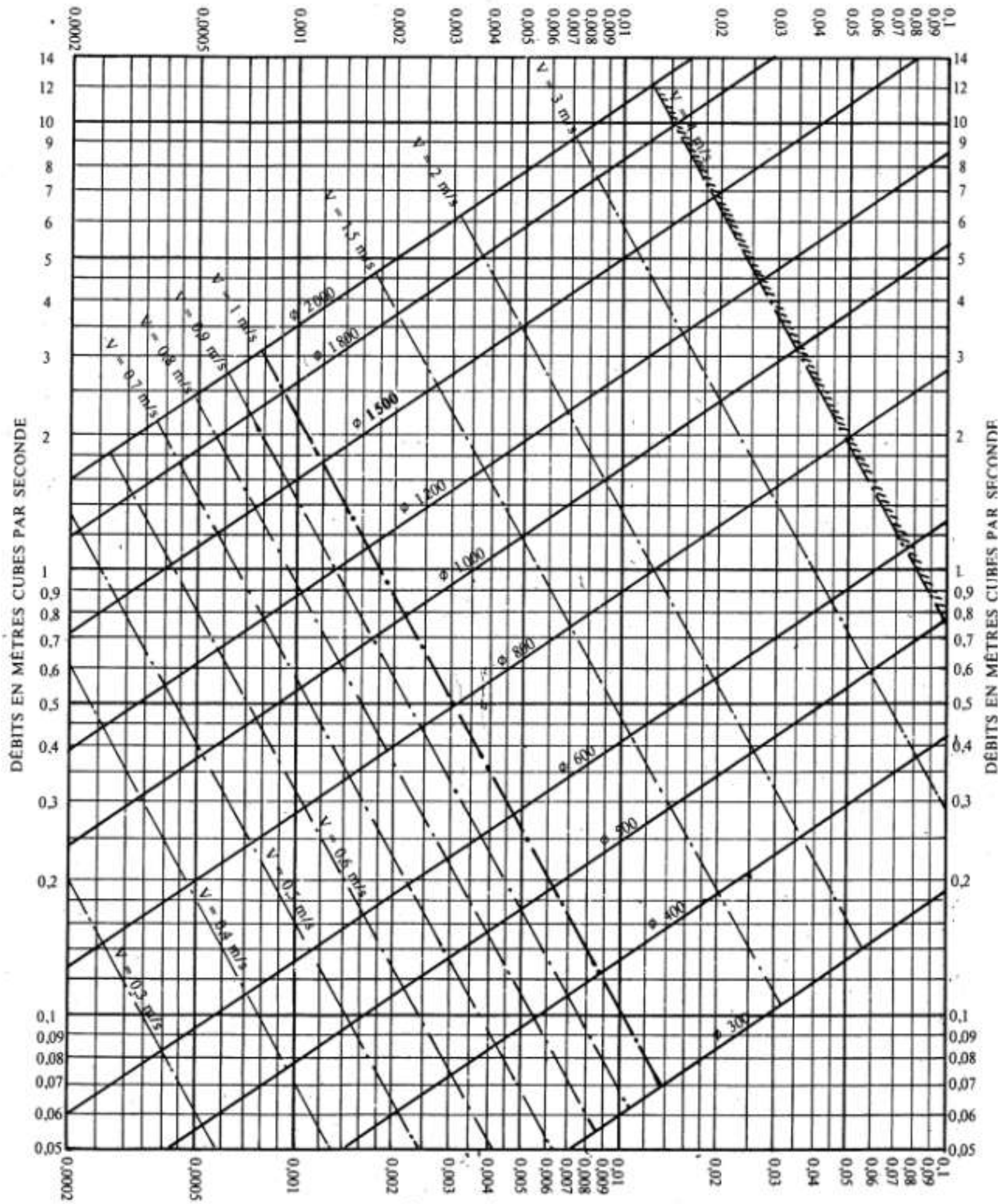
Nota. – La valeur du coefficient de Bazin a été prise égale à 0,25. Lorsque la pose des canalisations aura été particulièrement soignée, et surtout si le réseau est bien entretenu, les débits pourront être majorés de 20 % (γ = 0,16). A débit égal, les pentes pourront être réduites d'un tiers.

ABAQUE Ab. 4 a

Ab. 4a

RÉSEAUX PLUVIAUX EN SYSTÈME UNITAIRE OU SÉPARATIF

(Canalisations circulaires)



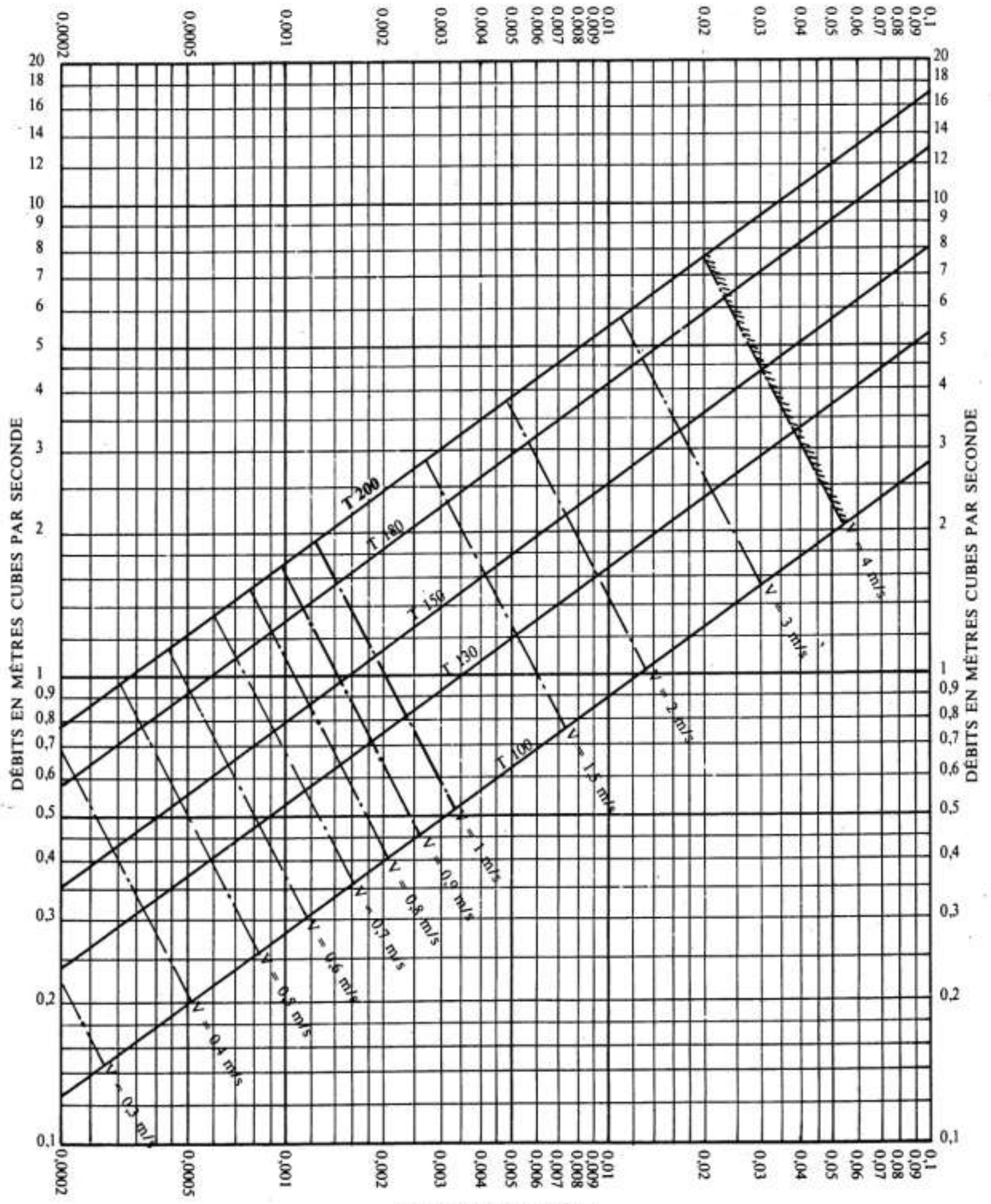
Nota. – La valeur du coefficient de Bazin a été prise égale à 0,46. Lorsque la pose des canalisations aura été particulièrement soignée, et surtout si le réseau est bien entretenu, les débits pourront être majorés de 20 % (γ = 0,30). A débit égal, les pentes pourront être réduites d'un tiers.

ABAQUE Ab. 4 b

Ab. 4b

RÉSEAUX PLUVIAUX EN SYSTÈME UNITAIRE OU SÉPARATIF

(Canalisations ovoïdes)

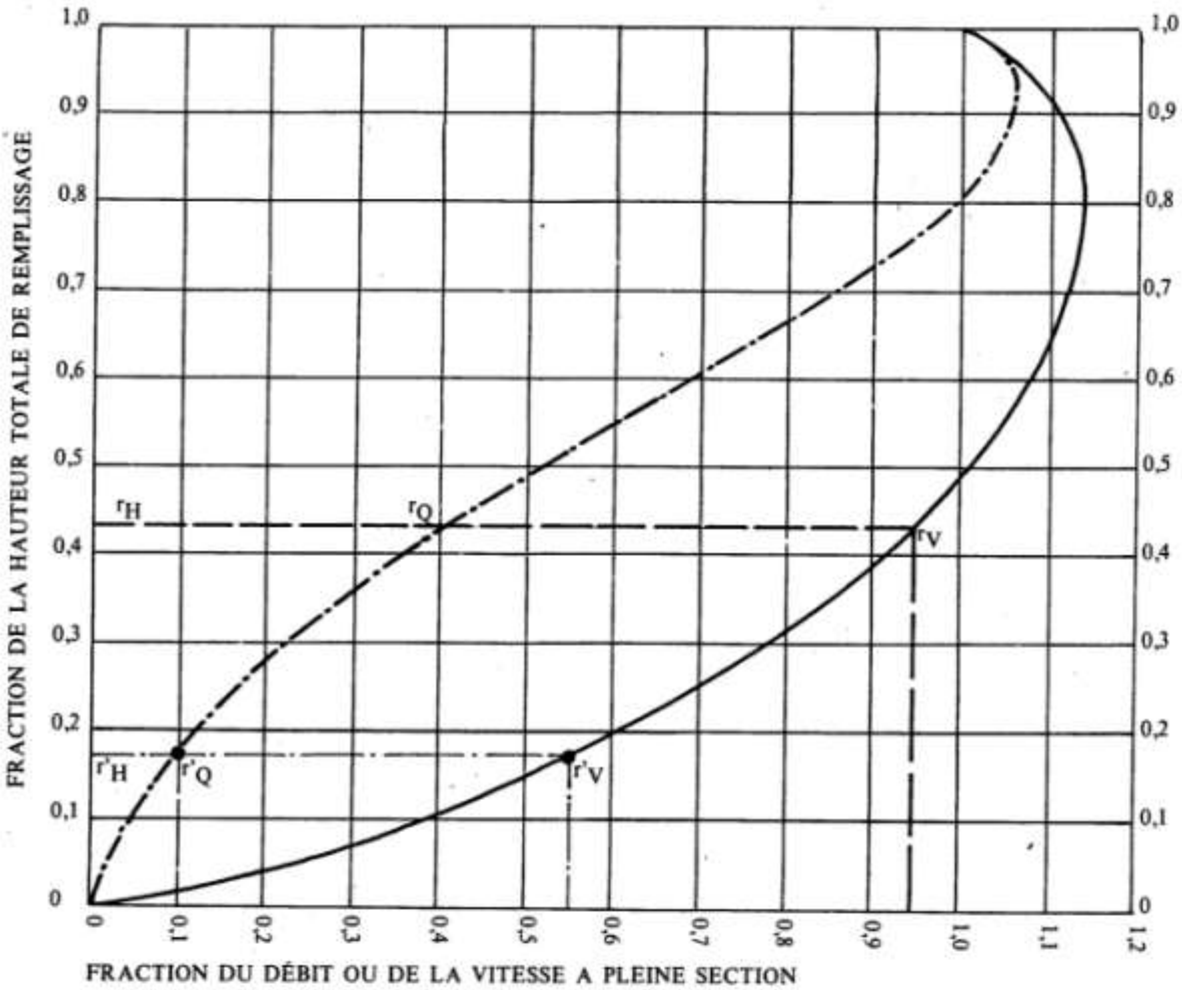


Nota. – La valeur du coefficient de Bazin à été prise égale à 0,46. Lorsque la pose des canalisations aura été particulièrement soignée, et surtout si le réseau est bien entretenu, les débits pourront être majorés de 20 % (γ = 0,30). A débit égal, les pentes pourront être réduites d'un tiers.

ABAQUE Ab. 5 — Ab. 5 *(a)*

VARIATIONS DES DÉBITS ET DES VITESSES EN FONCTION DU REMPLISSAGE

a) Ouvrages circulaires



MODE D'EMPLOI.

Les abaques Ab. 3 et Ab. 4 (*a* et *b*) utilisés pour le choix des sections d'ouvrages, compte tenu de la pente et du débit, permettent d'évaluer la vitesse d'écoulement à pleine section.

Pour l'évaluation des caractéristiques capacitaires des conduites, ou pour apprécier les possibilités d'autocurage, le nomogramme ci-dessus permet de connaître la vitesse atteinte en régime uniforme pour un débit inférieur à celui déterminé à pleine section.

Les correspondances s'établissent, soit en fonction de la fraction du débit à pleine section, soit en fonction de la hauteur de remplissage de l'ouvrage.

Exemples :

Pour r_Q = 0,40, on obtient r_V = 0,95 et r_H = 0,43.

Pour $Q_{PS}/10$, on obtient **r'_V = 0,55 et r'_H = 0,17 (autocurage).**

Nota. — Pour un débit égal au débit à pleine section, la valeur du rapport r_Q = 1,00 est obtenue avec r_H = 0,80.

Le débit maximum (r_Q = 1,07) est obtenu avec r_H = 0,95.

La vitesse maximum (r_V = 1,14) est obtenue avec r_H = 0,80.

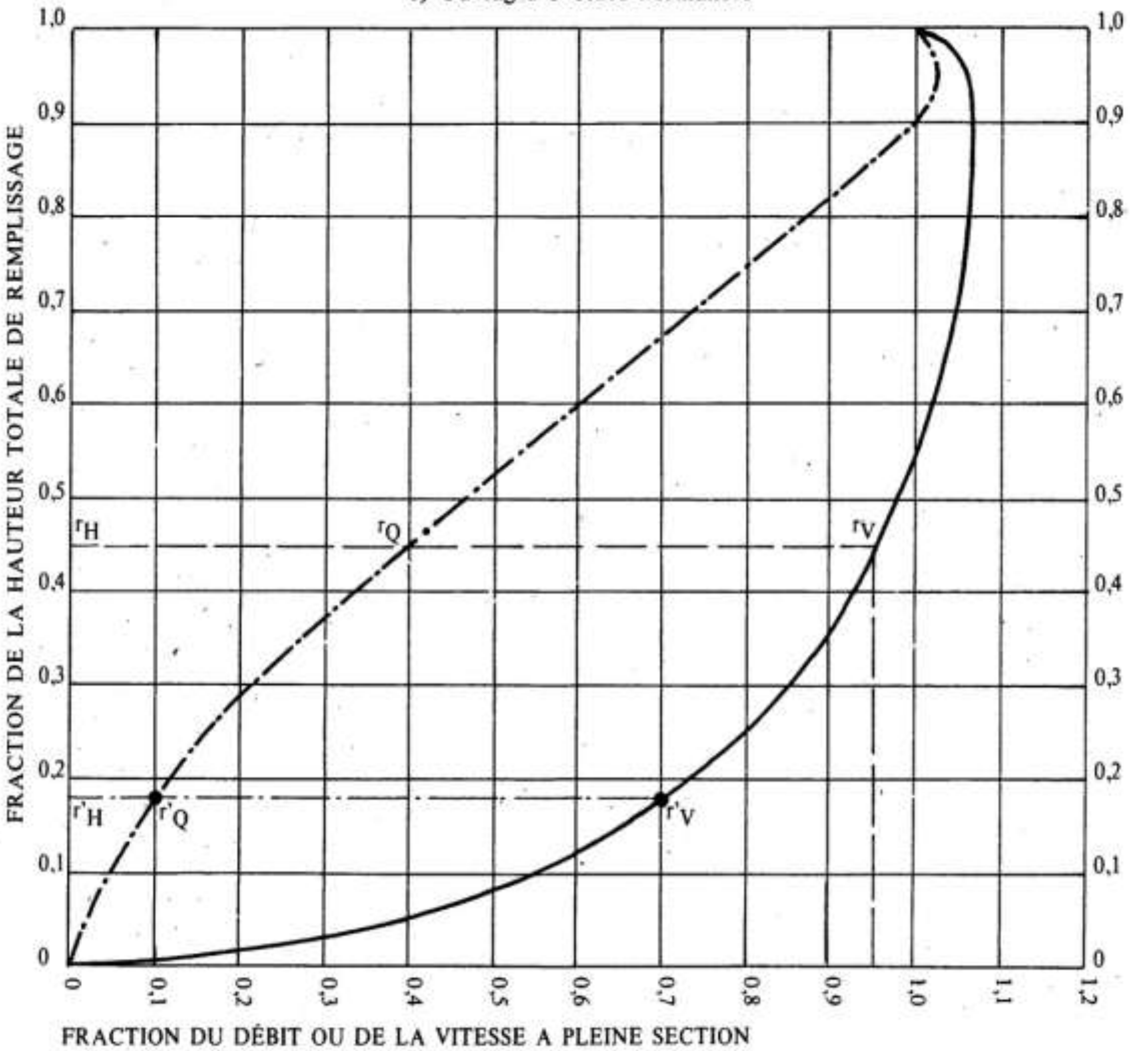
Ces dernières conditions d'écoulement à caractère assez théorique ne peuvent être obtenues que dans des conditions très particulières d'expérimentation.

ABAQUE Ab. 5

Ab. 5 *(b)*

VARIATIONS DES DÉBITS ET DES VITESSES EN FONCTION DU REMPLISSAGE

b) Ouvrages ovoïdes normalisés



MODE D'EMPLOI.

Les abaques Ab. 3 et Ab. 4 (*a* et *b*) utilisés pour le choix des sections d'ouvrages, compte tenu de la pente et du débit, permettent d'évaluer la vitesse d'écoulement à pleine section.

Pour l'évaluation des caractéristiques capacitaires des conduites, ou pour apprécier les possibilités d'autocurage, le nomogramme ci-dessus permet de connaître la vitesse atteinte en régime uniforme pour un débit inférieur à celui déterminé à pleine section.

Les correspondances s'établissent, soit en fonction de la fraction du débit à pleine section, soit en fonction de la hauteur de remplissage de l'ouvrage.

Exemples :

Pour $r_Q = 0{,}40$, on obtient $r_V = 0{,}95$ et $r_H = 0{,}45$.

Pour $Q_{PS}/10$, on obtient $r'_V = 0{,}70$ et $r'_H = 0{,}18$ (autocurage).

Nota. – Pour un débit égal au débit à pleine section, la valeur du rapport $r_Q = 1{,}00$ est obtenue avec $r_H = 0{,}90$.

Le débit maximum ($r_Q = 1{,}03$) est obtenu avec $r_H = 0{,}95$.

La vitesse maximum ($r_V = 1{,}07$) est obtenue avec $r_H = 0{,}90$.

Ces dernières conditions d'écoulement à caractère assez théorique ne peuvent être obtenues que dans des conditions très particulières d'expérimentation.