Centre Universitaire Abdelhafid Bousouf - Mila

2024-2025 Semestre 1

Distribution et collecte des eaux :

A PARTIE II : Assainissement

– Cours 6 –

Chapitre 06 : : *Méthodologie de diagnostic du réseau d'assainissement urbain.*



Staff pédagogique			
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Institut	**Département**	**Année**	**Spécialité**
Sciences et Technologie	GC et hydraulique	2eme année master	Hydraulique urbaine

Objectifs du cours 1

Chapter objective

This chapter formalizes the overall diagnostic approach for a wastewater network to assess its asset, structural, and hydraulic condition. It is structured around five key steps:

1. **The preparatory phase:** Collection of existing data (GIS, plans, intervention histories).
2. **Non-destructive investigation:** Visual inspection by camera (current standards) and search for incorrect connections.
3. **Hydraulic analysis:** In situ measurement campaigns (flow measurement) and modelling to identify overloads and parasitic inputs.
4. **Structural assessment:** Quantification of defects and prioritization of emergencies via criticality indices.
5. **The action plan:** Defining intervention strategies (cleaning, trenchless rehabilitation or replacement) to optimize investments and ensure the sustainability of the system.

XI.1. Introduction

The sewage system is a complex system subject to various forms of degradation, such as deposits, blockages, leaks, cracks, deformations, corrosion, and faulty connections. These anomalies can reduce its hydraulic performance and cause overflows, flooding, nuisances, and pollution risks.

Diagnosis is therefore an essential step in the management and preservation of the network. It allows for the assessment of its condition, the identification of malfunctions and their causes, and then the definition of the necessary interventions.

This approach is based on the analysis of available data, field observations, inspection of structures, hydraulic measurements and, if necessary, network modeling. **(EN 13508-2, 2011; Butler et al., 2018).**

XI.2. Definition and objectives of the diagnosis

The diagnosis of a sanitation network can be defined as the set of investigations and analyses enabling the determination of the condition, performance and malfunctions of a

sanitation system, in order to define the actions necessary for its maintenance, rehabilitation or extension.

XI.3. General organization of a diagnostic approach

A complete diagnostic process can be organized into several successive phases:

Phase 1: Data Collection and Analysis
↓
Phase 2: Reconnaissance and Preliminary Inspection
↓
Phase 3: Field investigations and measurements
↓
Phase 4: Hydraulic Diagnosis
↓
Phase 5: Structural and functional diagnosis
↓
Phase 6: Identifying the causes of malfunction
↓
Phase 7: Prioritizing anomalies
↓
Phase 8: Development of the action plan

This organization helps avoid costly investigations when available information already explains certain malfunctions. **(Bourrier et al., 2017; Ministry of Water Resources and the Environment, 2016).** (See Figure XI.01).

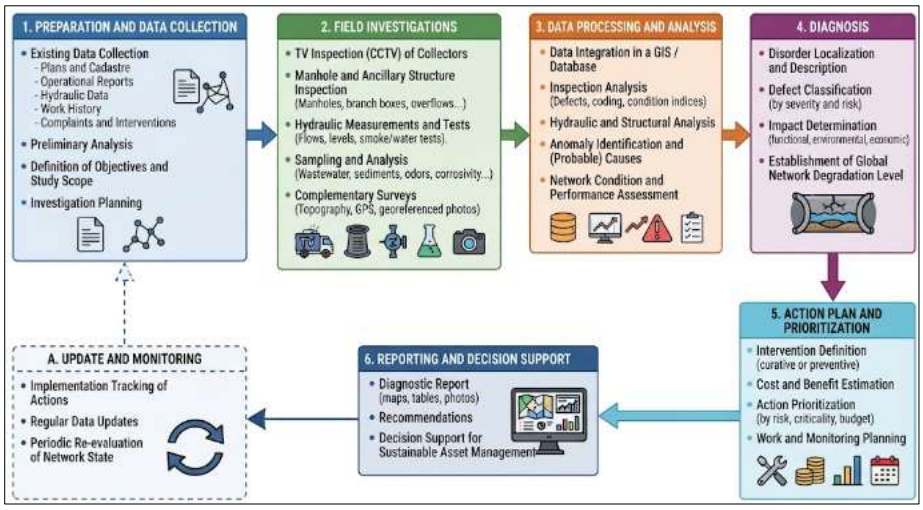


Figure XI.01. General diagram of the diagnostic methodology of an urban sanitation network. CERTU, 2003).

XI.4. Phase 1: Collection and analysis of existing data

The first step is to gather all available information about the network. (See Figure XI.02).

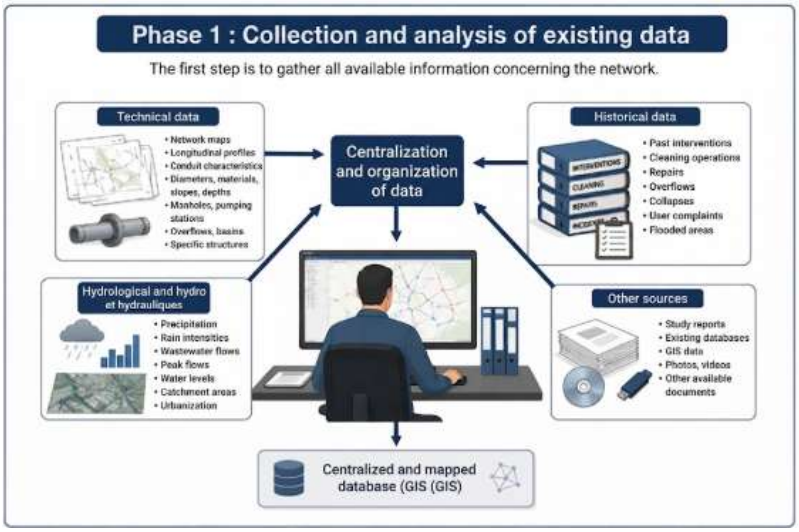


Figure XI.02. Phase 1: Collection and analysis of existing data . (Gabert et al., 2018)

XI.4.1. Technical Data

The technical data includes, in particular:

- Network plans;
- As-built drawings;
- Longitudinal profiles;
- The characteristics of the pipes;
- The diameters;
- The materials;
- The slopes;
- The depths;
- The looks;
- Pumping stations;
- The spillways;
- Storage basins;
- Special works.

When plans are available in digital format, a Geographic Information System (GIS) can be used to centralize and spatialize the information.

XI.4.2. Historical Data

Operational records are also important. They can provide information regarding:

- Previous interventions;
- Dredging operations;
- The repairs;
- The incidents;
- The excesses;
- The collapses;
- User complaints;
- Areas that regularly flood.

The repetition of the same incident on a pipeline constitutes an important indication that may justify a thorough investigation. **(Bourrier et al., 2017; Ministry of Water Resources and the Environment, 2016).**

XI.4.3. Hydrological and hydraulic data

The diagnosis must also include:

- Rainfall;
- Rainfall intensities;
- Waterproofed surfaces;
- Wastewater flow rates;
- Peak flow rates;
- Water levels;
- The characteristics of watersheds;
- Potential developments in urbanization.

This data makes it possible to verify whether the problems observed result from insufficient hydraulics or physical degradation of the network.

XI.5. Phase 2: Site Reconnaissance

Field reconnaissance allows the available theoretical information to be compared with the actual situation. (See Table XI.01; Figure XI.03).

It consists in particular of:

- Locate the gazes;
- Check their accessibility;
- Identify the missing or buried mansions;
- Check the apparent diameters;
- Observe the flows;
- Locate the deposits;
- Look for signs of overflow;
- Identify bad odors;
- Observe the leaks;
- Identify any anomalies in the structures.

This phase also allows for updating the network plan. **(Gabert et al., 2018; ASTEE, 2011).**

Table XI.01. Main observations made during the field reconnaissance.

Element observed	Anomalies sought
Regards	Degradation, obstruction, infiltration
Pipelines	Deposits, cracks, deformation
Drains	Clogging, poor connection
Outlets	Erosion, obstruction, abnormal discharge
Pumping stations	Breakdowns, overload, malfunction
Weirs	Abnormal operation, frequent emissions



Figure XI.03. Phase 2: Site reconnaissance. (ASTEE, 2011).

XI.6. Phase 3: Network Inspection

Inspection is an essential step in the diagnosis. It can be carried out using different methods depending on the type of network, its accessibility, and the level of precision required.

XI.6.1. Visual Inspection

Visual inspection involves examining manholes and accessible parts of the network.

It allows for the detection of, among other things:

- The deposits;
- Obstructions;
- The visible cracks;
- Infiltrations;
- The deterioration of the concrete;
- Corrosion;
- Faulty connections;
- Sealing defects.

This method is simple and relatively inexpensive, but it remains limited to accessible parts. (Bourrier et al., 2017)

XI.6.2. Television Inspection

When the geometry and accessibility of the network allow, a television inspection (TVI) can be carried out using a camera inserted into the pipe. (See Figure XI.04).

It allows observation of the internal condition of the pipe along its entire length.

The main anomalies being sought are:

- Cracks;
- Breaks;
- Deformations;
- Ovalization;
- Collapses;
- Root penetration;
- Deposits;
- Penetrating connections;
- Seal defects;

- Infiltrations ;
- Exfiltrations.

Observations are generally recorded in video format and associated with metric tracking. **(ASTEE, 2011; Bourrier et al., 2017).**

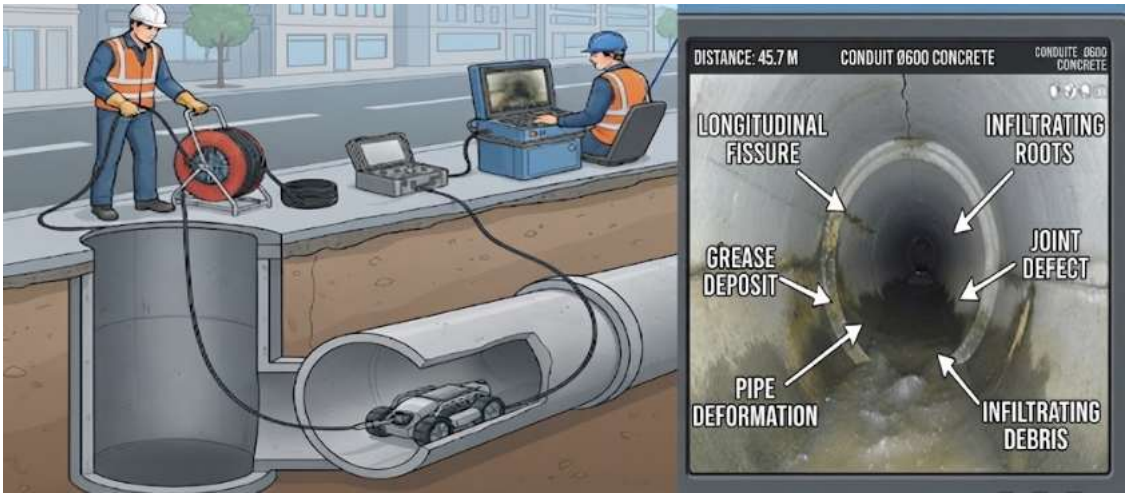


Figure XI.04. Television inspection of a sewer pipe using a camera. **(Bourrier et al., 2017)**

XI.7. Structural Diagnosis

Structural diagnosis aims to determine the capacity of the pipeline or structure to maintain its mechanical integrity.

The main structural defects are:

XI.7.1. Cracks

Cracks can be longitudinal, transverse, or irregular. Their importance depends in particular on their width, length, and location.

XI.7.2. Deformation

Flexible pipes can develop ovalization or deformation of their cross-section. This can reduce hydraulic capacity and gradually compromise the stability of the pipeline.

XI.7.3. Rupture and collapse

Breakages can result from excessive loads, ground movements, installation defects, aging, or corrosion phenomena. **(Bourrier et al., 2017; Ministry of Water Resources and the Environment, 2016).**

XI.7.4. Corrosion

Corrosion is particularly important in some wastewater networks. It can affect metallic materials as well as concrete structures under certain chemical conditions.

XI.7.5. Seal defects

Leaks at the joints can promote: (See figure XI.05).

- Groundwater infiltration;
- Wastewater exfiltration;
- Fine particle entrainment;
- Destabilization of the ground around the pipe. **(Hvitved-Jacobsen et al., 2013; Bourrier et al., 2017).**

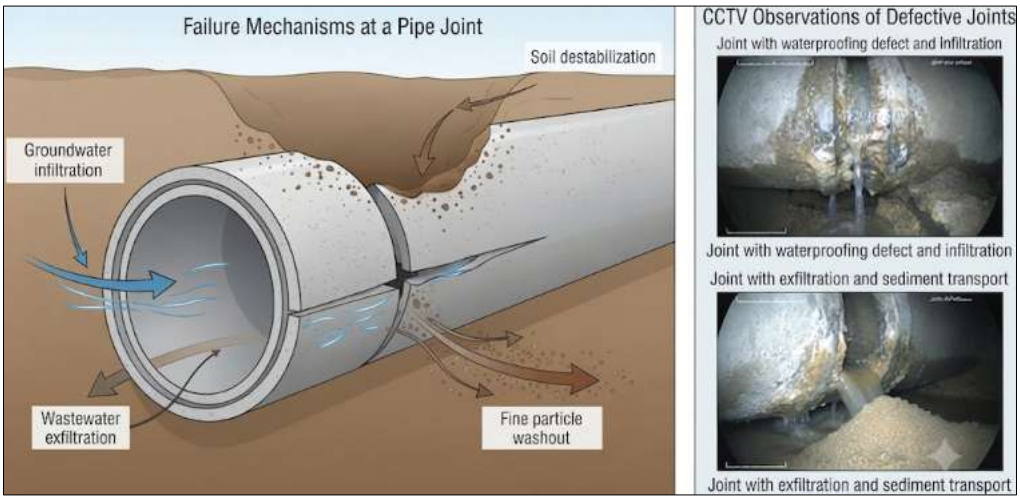


Figure XI.05. Sealing defects at the joints.

XI.8. Functional and hydraulic diagnosis

Hydraulic diagnosis consists of determining whether the network is capable of properly ensuring the evacuation of effluents under normal conditions and during rain events. **(Butler et al., 2018)**

It focuses in particular on:

- The flow rates;
- Flow velocities;
- Water levels;
- The charging;
- The capacities of the pipes;
- The excesses;
- Local shortcomings.

XI.8.1. Flow rate analysis

Flow rates can be determined from:

- Direct measures;
- Water consumption data;
- Continuous measurements;
- From gauging campaigns;
- Hydraulic models.

Comparing observed flow rates with theoretical pipe capacities helps identify areas that may be undersized. (See Figure XI.06).

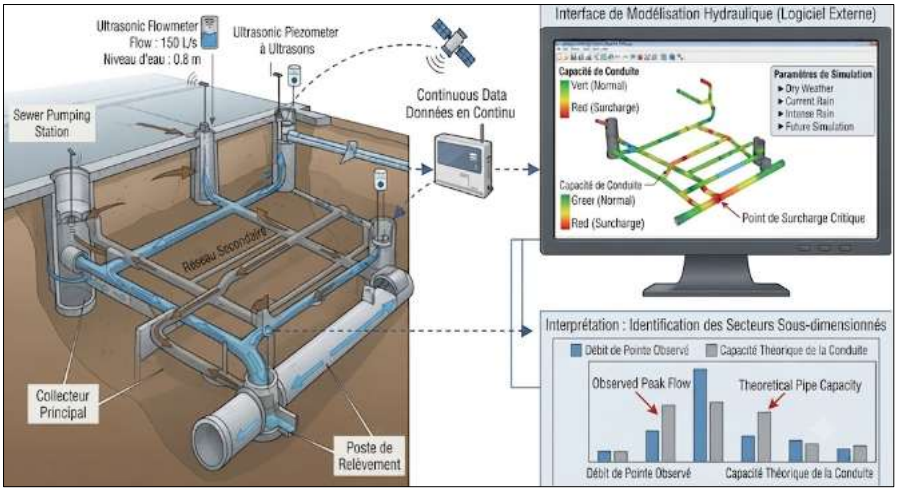


Figure XI.06. Instrumentation and hydraulic modeling of the network. (Bourrier et al., 2017)

XI.8.2. Search for parasitic waters

Extraneous water is a major problem for sanitation networks.

They can be:

- Permanent parasitic clear waters;
- Infiltration water;
- Drainage water;
- Runoff water connected illegally;
- Parasite meteoric waters.

They lead to an unnecessary increase in transported flows and can cause overloading of collectors and wastewater treatment plants.

Comparing nighttime flows, dry flow rates, and rainy flow rates provides a first approach to identifying these inputs. (See Table XI.02).

Table XI.02. Identification of extraneous waters by comparison of flow rates. (Bourrier et al., 2017)

Observation period	Flow rate behavior	Type of suspected contribution	Diagnostic indicator	Interpretation
Nighttime period	Abnormally high flow rate despite low consumption	Clear water with permanent parasitic seepage / infiltration	High nighttime flow rate	Probable presence of continuous inputs into the network
Dry weather – day	Speed higher than expected domestic speed	Infiltration, drainage or unauthorized connections	Excess dry weather flow	Contribution of permanent parasitic water
After a rainy period	Gradual increase in flow rate	Water infiltration through joints, cracks or leaks	Delayed increase in flow rate	Slow response characteristic of infiltrations
During the rain	Rapid and significant increase in flow rate	Illegally connected runoff / faulty connections	Peak flow synchronized with rainfall	Probable presence of meteoric parasitic waters
After the rain	Maintaining a high flow rate for several hours	Infiltration and drainage	Slow decrease in flow rate	Storage and subsequent delayed release of infiltrated water
Dry weather – low flow	Flow rate close to the theoretical domestic flow rate	Absence or low presence of extraneous water	Small difference between measured flow rate and expected flow rate	Network operation is relatively normal

XI.9. Hydraulic modeling of the network

When the network presents a certain complexity, hydraulic modelling is an important diagnostic tool. (See figure XI.07).

It allows you to simulate the behavior of the network under different conditions:

- Dry weather;
- Rainfall;
- Heavy rain;
- Future situation;
- Increase in impermeable surfaces;
- Modification of wastewater flow rates.

Hydraulic models allow us to identify, in particular:

- Overloaded pipes;
- Overflow points;
- Undersized sectors ;
- The stored volumes;

- Water levels;
- Hydraulic constraints.

However, a model should not be used without validation. The results must be compared with observations and measurements made in the field.

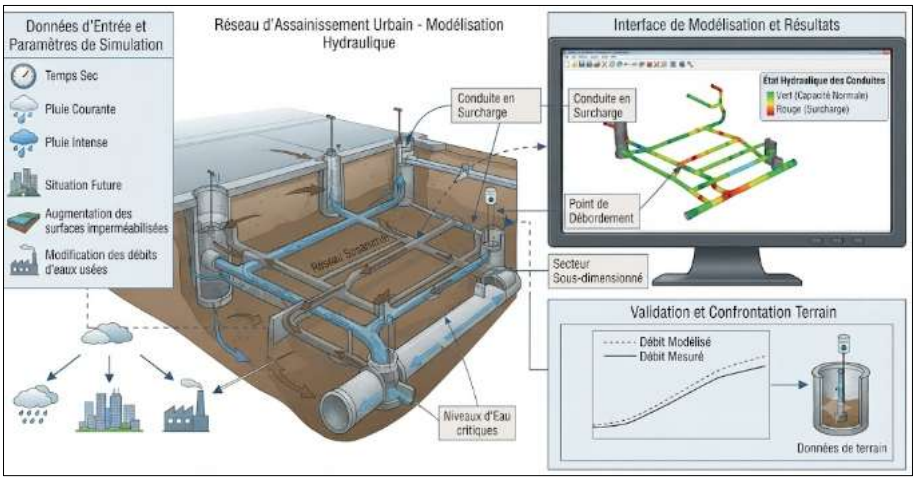


Figure XI.07. Hydraulic modeling and validation of the sanitation network

XI.10. Identification and classification of malfunctions

After the various investigations, the anomalies must be identified and classified. We can distinguish four main categories. (See table XI.03). **(Gabert et al., 2018; CERTU, 2003).**

Table XI.03. Classification of the main malfunctions.

Category	Examples
Structural	Crack, rupture, collapse, deformation
Hydraulic	Undersizing, overloading, loading
Functional	Deposits, blockages, roots, poor drainage
Waterproofing	Infiltration, exfiltration, faulty seal

This classification then facilitates the determination of corrective measures.

XI.11. Prioritization of anomalies

Not all the observed anomalies present the same level of severity. It is therefore necessary to prioritize them.

The prioritization can take into account:

- The severity of the defect;
- The probability of evolution;
- The risk of collapse;
- The frequency of incidents;
- The population concerned;
- The environmental consequences;
- The hydraulic importance of the pipeline;
- The potential cost of the damages.

We can define, for example, three levels of priority:

Priority 1: Urgent intervention

It concerns anomalies that present a significant risk to safety, the environment, or service continuity.

Examples:

- Imminent collapse;
- Major obstruction;
- Frequent overflows;
- Significant infiltration;
- A break in strategic conduct.

Priority 2: Short-term intervention

It concerns anomalies that could cause a progressive degradation in the functioning of the network.

Priority 3: Monitoring and maintenance

It concerns minor defects that do not require immediate intervention.

XI.12. Development of the rehabilitation program

The final stage of the diagnosis involves transforming the results of the investigations into a program of action. **(Gabert et al., 2018; CERTU, 2003).**

Several solutions can be considered:

1. **Interview**

- Dredging;

- Cleaning;
- Clearing blockages;
- Root removal.

2. Repair

- Occasional repair;
- Replacing a seal;
- Repairing a crack;
- Reconnecting a connection.

3. Rehabilitation

- Shirting;
- Tubing;
- Pipe replacement;
- Rehabilitation of the gaze.

4. Hydraulic reinforcement

- Increase in diameter;
- Creating a new collector;
- Setting up a storage system;
- Modification of hydraulic operation.

Conclusion

The diagnosis of sanitation networks is based on a comprehensive approach integrating the state of the infrastructure, field observations, structural aspects and hydraulic operation.

It allows for the identification of malfunctions, the investigation of their causes, and the prioritization of interventions. The combined use of CCTV inspections, hydraulic measurements, GIS, and hydraulic modeling helps improve the reliability of the diagnosis and direct investments toward the most critical areas, thereby reducing the risks of failure, pollution, and flooding.

Liens utiles

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