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Strategic Asset Management

Rehabilitation of a large sewer: methodology for the Alcântara interceptor sewer

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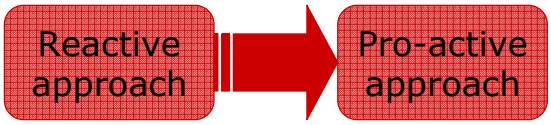
INTRODUCTION

Pro-active rehabilitation is recognised as a key step for reduction of risk associated with water infrastructures.

Challenge:

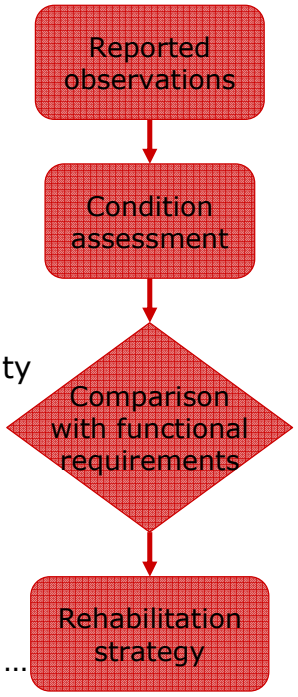
- Definition of appropriate strategy
- Adequate use of limited resources
- Effective management and use of available information



INTRODUCTION

Methods to establish rehabilitation strategies:

- Full network inspection in a number of years
  - Justified in some cases (e.g. construction quality verification)
  - Requires extensive resources
  - Generates large amounts of data
- Selective inspections
  - Various approaches reported (physical modelling, regression analysis, probabilistic distribution functions, Marchov chain analysis, …
  - Most requiring extensive data sets



INTRODUCTION

Some reported issues on this approach:

- Reliability of the detection and coding of symptoms, depending on factors such as,
  - Qualifications and concentration of operator, technology used, conditions during inspection, …
- Adequacy of the method used to assess the functional condition,
  - Large amount of data, recognition observations relevant to priority situations, transferability of approaches, …
- Resources are not optimised or directed to priority situations

INTRODUCTION

Large sewers (≥ 1.5m) pose specific problems:

- Person-entry inspection necessary
- Pre-inspection works are complex and expensive (e.g. cleaning operations)
- Structural behaviour is case specific
- Failure and rehabilitation often results in severe consequences (public safety, financial, social, environmental)

Thus,

- Early detection of critical situations is essential
- Minimisation of inspections is aimed

INTRODUCTION

Specially for large sewers, understanding of **deterioration mechanisms** and identification of influencing factors for specific sewers, allows:

- Plan selective inspections based on expected behaviour, available information and case specific factors
- Identification of specific symptoms during visual inspections – allows to perform a more selective data analysis

INTRODUCTION

Looking into **structural deterioration** of sewers, factors to be considered include:

- **Design and construction** – structural design, installation method, standard of workmanship, sewer size, sewer depth, bedding material and type, sewer pipe material, joint type and material, pipe section length, connections
- **Local external** – surface land use, surface loading, surface type, traffic characteristics, water main burst/leakage, ground movement, maintenance of other buried services, groundwater level, infiltration/exfiltration, soil backfill type, root interference
- **Internal functional** – hydraulic behaviour, sewage characteristics, sediment level
- **Maintenance and operational** – insufficient or inappropriate maintenance practices, asset age

OBJECTIVE

Development of a methodology to define rehabilitation strategies for large sewers, including:

- analysis of deterioration mechanisms
- identification of the associated specific symptoms, and
- selective visual inspection for confirmation of the approach

Specific objectives include:

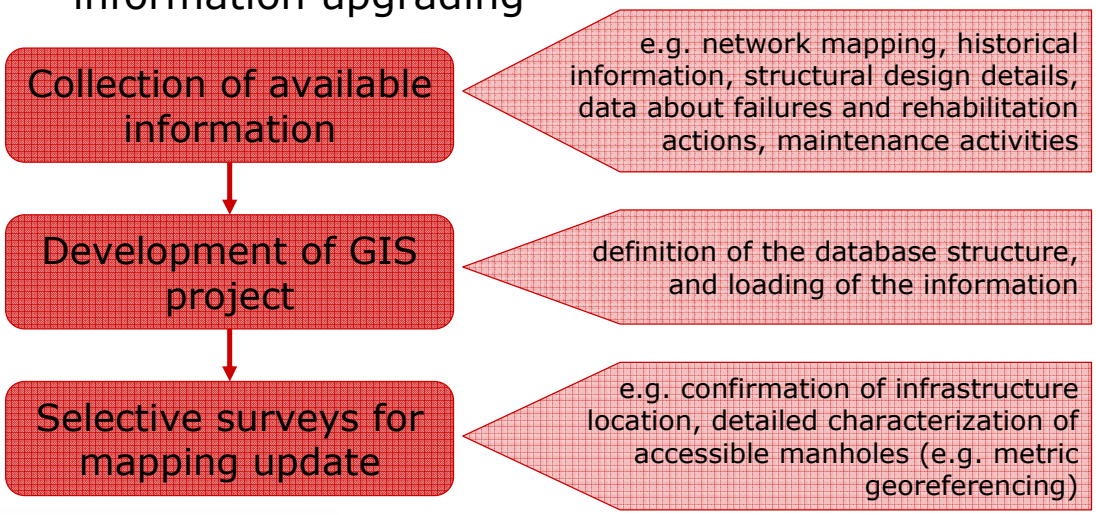
- procedure for overall infrastructure condition evaluation by means of a GIS system (spatial analysis)
- definition of an effective strategy for the timely detection of the critical situations (higher risk of structural failure)
- minimisation of time and costs of inspection

METHODOLOGY

- Planning of GIS project and data structure and information upgrading
- Mapping of structural problems (internal and external causes)
- Establishment and execution of a priori inspection plan
- Framework for rehabilitation and inspection priorities definition

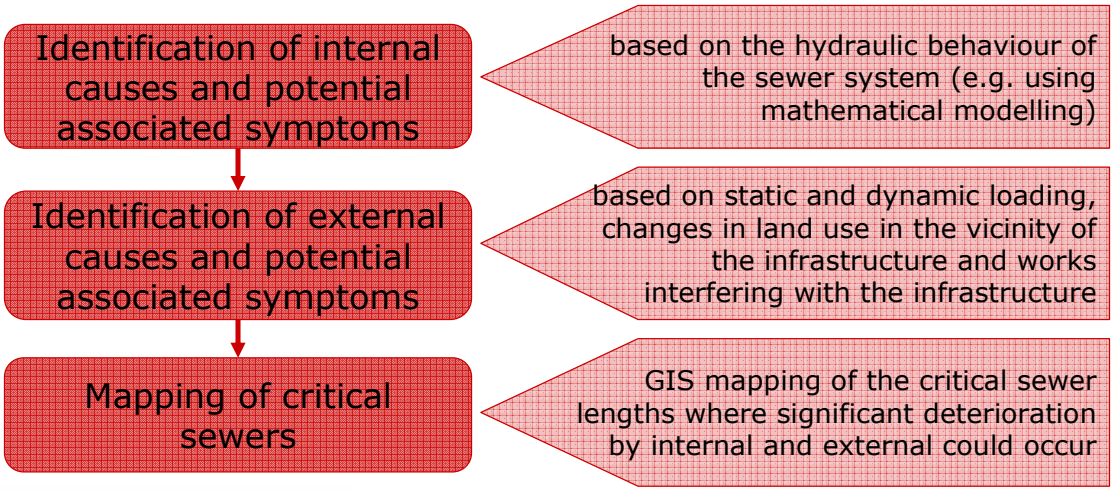
METHODOLOGY

- Planning of GIS project and data structure and information upgrading



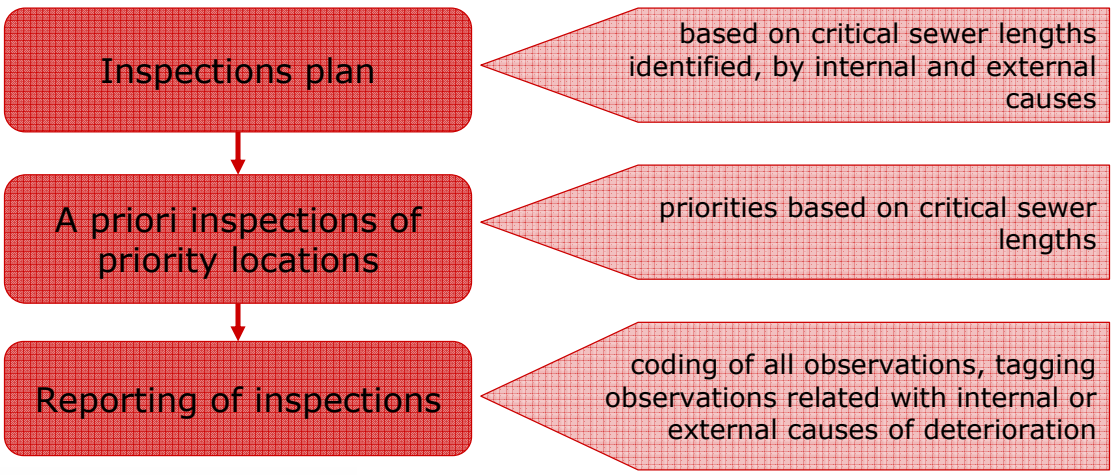
METHODOLOGY

- Mapping of structural problems (internal and external causes of deterioration)



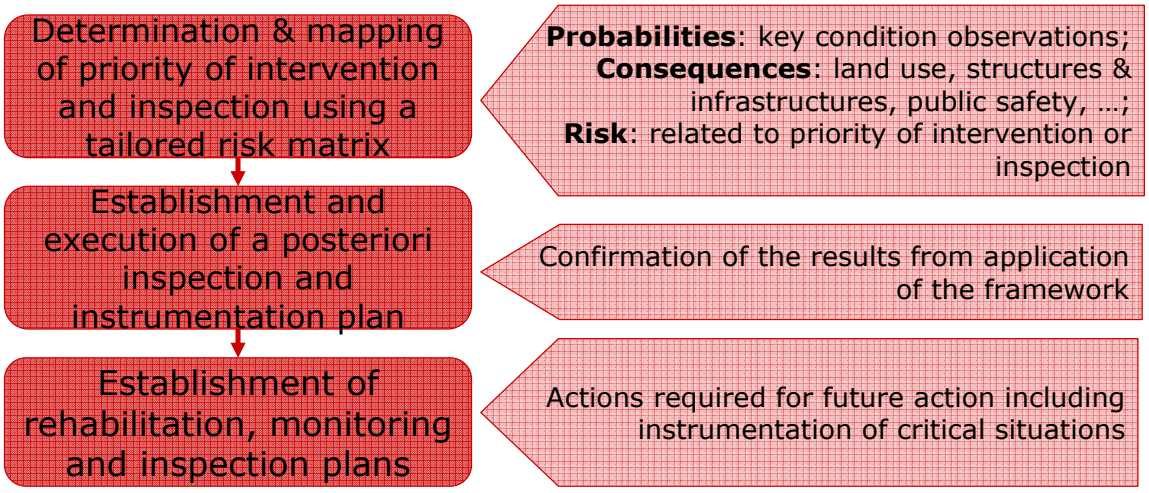
METHODOLOGY

- Establishment and execution of a priori inspection plan



METHODOLOGY

- Definition of framework for rehabilitation and inspection priorities



CASE STUDY

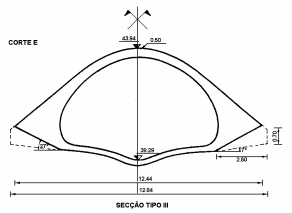
Alcântara interceptor sewer

- Alcântara Stream was covered between 1944 and 1967
  - Combined sewer
  - 10 km length interceptor sewer
  - Serviced area: 3200 ha
  - Predominant material: non-reinforced concrete
  - High flow velocities (dry and wet weather)
  - Increasing frequency of structural failures since 1990's

Alcântara interceptor

Sewer characteristics

- 'Caneiro' cross section
- Dimensions: up to 5.15m x 8 m
- Design (dry/wet weather):
  - flow: 2.5 / 213 m^3/s
  - velocity: 1.5 / >7 m/s
  - Flow depth: 0.7 / 5 m



Deterioration mechanisms

Internal causes

Physical, chemical and biochemical processes

Relevant factors:

- pipe fabric and dimensions
- composition and density of the flow
- type, size and form of the transported solids
- chemistry of the wastewater
- flow velocity
- angle of attach between solid particles and the pipe walling
- flow regime

Predominant: **mechanical wear (pipe invert)**

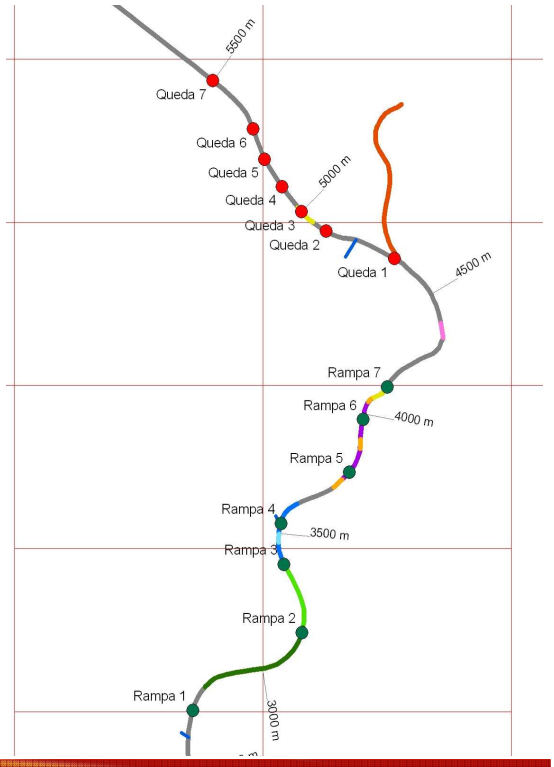
Internal causes: flushing wear

Critical sewer lengths were identified based on:

- Steep sewer lengths (e.g. 10% ramps)
- length immediately downstream of ramps and drops
- insertion of large sewers

Internal causes

- Past reactive rehabilitation actions associated with identified internal causes
- A priori inspections revealed the expected symptoms
- Most critical situations found were due to internal causes
- Mechanical wear was also found to be significant in the dry weather flow channel (>40 years in service)



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Final remarks

- Understanding the mechanisms of deterioration of the sewers and identification of associated symptoms can be of large value especially in the case of large sewers
- The methodology used provides a way to reduce inspections and observations to be considered in the analysis, by a screening procedure associated with the type of mechanisms of degradation
- Use of GIS simplifies the tasks required for:
  - defining the rehabilitation strategy and program
  - programming of inspections minimising the risk of personnel
- Transparency in the analysis process is valued by the decision maker (qualitative risk matrix)