INFORMATION USE IN DUTCH SEWER ASSET MANAGEMENT

Van Riel WAP [a]*, Langeveld JG [a,b], Herder PM [c] and Clemens FHLR [a,d]

[a] Section Sanitary Engineering, Faculty of Civil Engineering and Geosciences, Delft University of Technology, PO Box 5048, 2600 GA, Delft, The Netherlands
[b] Royal HaskoningDHV, PO Box 151, 6500 AD, Nijmegen, The Netherlands
[c] Section Energy and Industry, Faculty of Technology, Policy and Management, Delft University of Technology, PO Box 5015, 2600 GA, Delft, The Netherlands
[d] Witteveen+Bos Consulting Engineers, PO Box 233, 7400 AE, Deventer, The Netherlands

* Corresponding author: WAP van Riel, e-mail: w.a.p.vanriel@tudelft.nl

Sewer systems are capital-intensive infrastructures, requiring appropriate asset management to safeguard serviceability. In the Netherlands, effective sewer asset management is described by De Leeuw's control paradigm. Reliable data and information are key elements in decision-making for rehabilitation and renewal of the assets. Rehabilitation is often based on limited asset condition information. Although various sources described procedures for guiding decision-making for rehabilitation, it remains unclear which and how information sources are used in this process, and to what extent value trade-offs influence decisions. In order to improve current sewer asset management, this study assesses the availability and use of information in decision-making for sewer system renewal in the Netherlands. Eighteen interviews were conducted at seven municipalities, combined with an analysis of their municipal sewerage plans. The interviewees described the decision-making process and the information sources they use in this process. Decisions for sewer system renewal are often based on intuition in implicit risk analyses, where risk is defined as 'feeling times consequence'. Sewer asset management is ineffective, because it relies mostly on intuition, hampering justification, accountability and repetition of decisions and preventing evaluation. Evaluation procedures and a critical attitude towards relevancy and quality of information are recommended.

Keywords: asset management, sewer system management, information use, decision-making

1. INTRODUCTION

Sewer systems are capital-intensive infrastructures, with a design service life between fifty and ninety years, requiring appropriate asset management to maintain system serviceability and minimize costs for rehabilitation. Asset management is described, for example by PAS 55 [1], which is set up aiming at maximizing profits of Anglo-Saxon businesses. Brown and Humphrey [2] describe asset management as balancing performance, cost and risk.

In the Netherlands, sewer asset management has developed differently compared to other countries, because of two reasons. First, Dutch municipalities are responsible for collection and transportation of wastewater, including operation and maintenance of sewer systems. Municipalities are asset owner and asset manager. The treatment of wastewater is a responsibility of waterboards. The costs for municipal sewerage are fully covered by issuing taxes to households and companies. Because a municipality's goal is not to maximize profit, PAS 55 seems unsuitable to apply for managing a public infrastructure within a governmental body. Second, in the 1980s, the Netherlands was one of the first countries where the importance of sewer asset management increased considerably, because of an emphasis shift from expansion to maintenance of infrastructure serviceability [3]. This shift was initiated by the fact that in the 1980s, a sewer connectivity of 90 % was reached and further network expansion was no longer driving the sector. By the work of Oomens [4] in the early 1990s, Dutch sewer asset management adopted principles of De Leeuw's [5] control paradigm, by reformulating sewer asset management as a control problem. This study adopted De Leeuw's control paradigm, in order to evaluate the development of sewer asset management since the 1990s. Another approach to assess organizational structures is by Mintzberg's organizational configurations. For the scope of this study, applying the control paradigm is appropriate. Shown in Figure 1, the paradigm states that a controller controls a system, both of which interact with their environment. Control is defined as any form of directed

influence. For sewer asset management, the controller is the department responsible for sewerage and the controlled system is the sewer system.

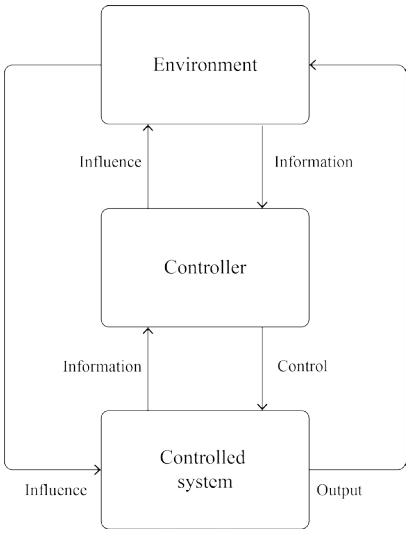

Figure 1. De Leeuw's control paradigm [5]

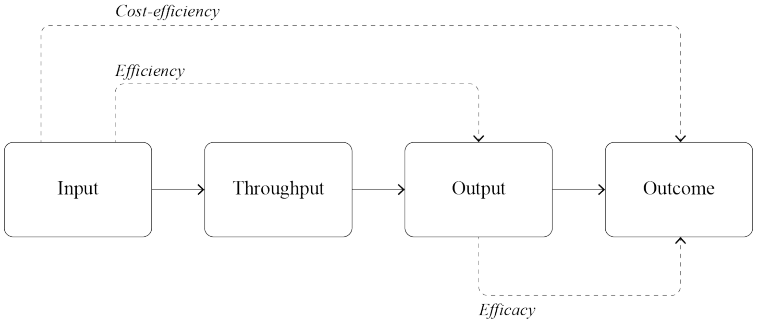

Figure 2. Evaluating organizations [6]

The controller's ability to successfully control its system depends on five preconditions for effective control. De Leeuw describes effective as "achieving the desired effect". Figure 2 depicts that as efficacy. Dutch sewer asset management focuses on cost-efficiency, which is defined as achieving a desired outcome at lowest costs.

1. The controller has an objective and an evaluation mechanism to check whether the goals are met.
2. The controller has a model of the controlled system to predict the effect of potential control actions.
3. The controller has information about the environment and the controlled system.
4. The controller has sufficient control actions to cope with the variability of the system.
5. The controller has sufficient information processing capacity to transform incoming information into effective control actions that are in line with the objectives.

Current guidelines for sewer asset management are described in the European Standard EN 752 [7] and, for the Netherlands, in Urban Drainage Guidelines. Dutch national legislation obligates municipalities to set up a sewerage plan every five years. These plans describe policy objectives and costs for managing the sewer system. Adoption of the full paradigm for sewer asset management has not been completed, affecting the procedures in EN 752, Dutch Urban Drainage Guidelines and the municipal sewerage plans. For example, an evaluation mechanism for rehabilitation measures is lacking, preventing sewer system managers from improving asset management practices.

Reliable data and information are key elements in guiding the complicated decision-making for rehabilitation of the physical sewer assets [8-10]. Asset managers are confronted with decreasing public acceptance, tighter available budgets, stricter legislation and increasing performance requirements [11]. More specifically for sewer asset management, the relation between sewer system works and other urban infrastructure works, such as road works, complicates planning in space and time [3, 12]. Decisions for rehabilitation of sewer systems are often based on limited asset condition information, such as pipe age and status, where camera inspections determine the status [12-16]. Anecdotal evidence suggests that municipalities in the Netherlands, also use other types of information in the decision making process, including hydraulic performance, citizens' complaints, urban renewal plans, available budget or working capacity.

Although the EN 752 and municipal sewerage plan describe the process of information use for rehabilitation decisions, the practical application is different. It is unclear which and how information sources are used in deciding upon sewer system rehabilitation, and to what extent rehabilitation decisions are influenced by value trade-offs. This observation is not different from any other decision-making process, but in order to improve current sewer asset management, this study assesses the availability and use of information in decision-making for sewer system rehabilitation projects in the Netherlands.

2. METHODS AND MATERIALS

The decision-making process and current use of information was assessed by interviewing sewer system managers at Dutch municipalities and analyzing their sewerage plans. Each municipal sewerage plan contains a specific section about sewer system renewal, including motivation and projected efforts. Information sources were extracted from these sections.

Twenty-one interviews were conducted at eight Dutch municipalities, ranging in population size from less than 10,000 inhabitants to over 750,000 inhabitants. The interviewed municipalities constitute approximately 15 % of total population in the Netherlands. Table 1 shows several characteristics of the municipalities included in this study. Employees at three organizational levels were interviewed (strategic, tactical and operational), reflecting potential differences in information use, decision-making and perspective towards asset management. Strategic management mainly addresses 'why' things are done. It is the management of aspects that are essential for the existence of an organization in its environment. This level is mainly concerned with defining and assessing middle and long-term objectives, strongly based on influence from the environment the organization is in. Tactical management is organizing and structuring tasks, necessary from strategic management. Operational management is governing that tasks, necessary from strategic and tactical management, are carried out most appropriately [17].

Table 1. Characteristics of interviewed municipalities

Municipality	Nr. of inhabitants at 01-01-2011 [18] (-)	Population density [19] (inh./km^2 of land)	Sewer length * (km)	Available budget for 2012 * (M Euro)	Available budget per inhabitant (Euro/inh.)	Available budget per km sewer pipe (K Euro/km)
Almere	190,655	1.469	1,100	8.7	45.6	7.9
Amsterdam	779,808	4.700	3,811	64.9	83.2	17.0
Barneveld	52,490	298	624	9.1	173.4	14.6
Breda	174,599	1.379	1,050	13.5	77.3	12.9
Ede	108,285	340	986	9.6	88.7	9.7
Rotterdam	610,386	2.987	2,906	51.2	83.9	17.6
The Hague	495,083	6.046	1,439	33.3	67.3	23.1

* Data is extracted from the municipal sewerage plan per municipality

A semi-structured interview schedule was used. During the interviews, two flowcharts were presented that visually assisted the interviewees during discussing the decision-making process for sewer renewal projects. Figure 3 shows these flowcharts. Four exploratory interviews were conducted to prepare the flowcharts. The starting point of each flowchart differs, related to information flow in the control paradigm. One flowchart starts with system information (system condition) and the other flowchart starts with environment information (other public works).

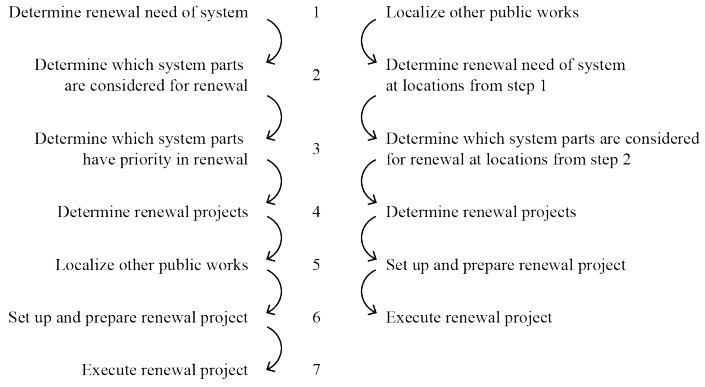

Figure 3. Flow charts used during interviews

Through the flowcharts, the following topics were addressed in chronological order: justification and completeness of flowcharts, information sources per step, budget allocation and identification of organizational levels. The interviewees described these topics based on their knowledge and experience.

3. RESULTS AND DISCUSSION

The interviewees indicated that the decision-making process for sewer system renewal consists projects of five steps, shown by Figure 4.

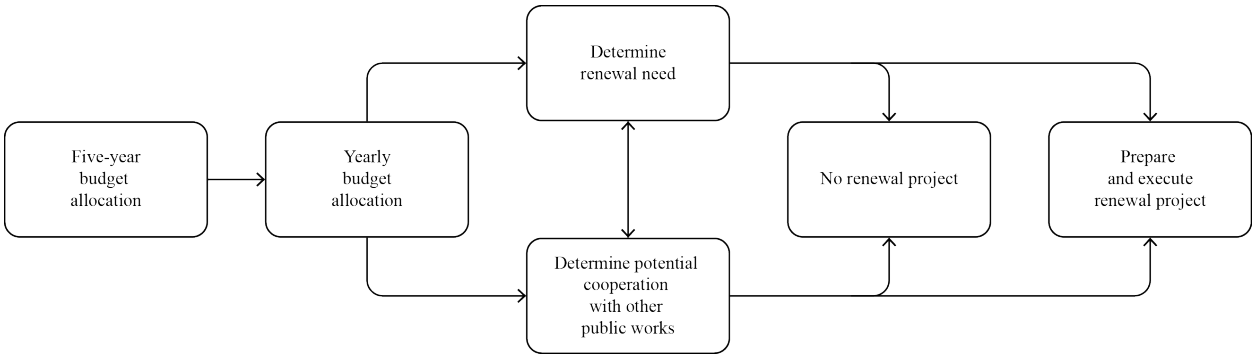

Figure 4. Decision-making process for sewer system renewal.

Figure 4 shows that the starting point is the five-year budget allocation. According to the municipal sewerage plans, this budget allocation for sewer system renewal is based on pipe age and camera inspections. The yearly budget is allocated as approximately one fifth of the five-year budget. After the budget is allocated, individual renewal projects are formulated, based on the renewal need and potential cooperation with other public works.

The interviewees mentioned twenty-two information sources they consider in deciding upon sewer system renewal. Table 2 shows twelve of the twenty-one identified information sources. These are the sources mentioned more than once. The information sources are categorized on the basis of the control paradigm, which distinguishes three categories: system, environment and organization information. This categorization is applied for this study.

Table 2. Identified information sources and identification frequency of eighteen interviews

Information category	Information source	Relative frequency (n = 18)
System	Camera inspection images	1.0
	Pipe age	0.9
	Hydraulic modelling	0.4
	Maintenance reports	0.4
	Function of sewer branch	0.2
Environment	Planning of public works	0.9
	Settlement rate	0.4
	Planning of urban development	0.4
	Citizens' complaints	0.3
	Traffic density of road above sewer	0.2
Organization	Experience and intuition	0.5
	Municipal water management strategy	0.2

Figure 4 shows discrepancy between strategic and operational decision-making. The budget is allocated before and on other grounds than the operational activities. On a strategic level, decision-making for renewal is based on pipe age and status. For the operational activities, sewer system managers try to cooperate with other public works as much as possible, usually with road works. This shift in controlled system complicates decision-making for sewer system managers.

Deciding upon the need for sewer system renewal is mostly based on pipe condition assessment by pipe age and camera inspection images. Experience and intuition form the basis for interpreting pipe age and camera inspections and converting these to renewal actions. Camera inspection is the only information source for which decision-making is normalized (European EN 13508-2 [20]), resulting in the intense use of it. Apart from the fact that camera inspections are unsuitable to judge about system performance, assessment of camera inspections images introduces significant uncertainty in the overall condition assessment [21]. Hydraulic modeling is used to check whether the hydraulic performance of the sewer system meets its objectives. Korving [22] showed that significant uncertainty for decision-making is introduced by hydraulic modeling. For municipalities located on soft soil, settlement is also used

for determining the need for renewal. Dirksen et al. [23] described the relation between settlement and sewer system performance. Yet, no reference model for settlement is available to assist in decision-making. In short, deciding upon the need for sewer system renewal is based on an implicit risk analysis of two aspects: pipe collapse and insufficient hydraulic performance.

Instead of a product of probability and consequence, the risk is determined by 'feeling times consequence'. A lack of insight in sewer deterioration processes causes sewer managers to avoid risks by renewing sewer pipes without knowing the remaining service life. Renewal decisions are ill-founded, because sewer system managers have insufficient insight in sewer deterioration processes and lack necessary information on sewer system condition and functioning [24]. In dealing with this issue, sewer renewal works integrate with other public works. Because of the risk aversive attitude, availability of sewer services is good compared to other utility services. The customer minutes lost in the Netherlands for sewer services is 0.2 minutes/customer/year, while for gas 0.4, drinking water 14.0 and electricity 28.9 minutes/customer/year [25]. The interviewees indicated they would like to be able to make predictions about the system's performance and structural condition to have more control over their system and planning of renewal works.

Integrating sewer works with other public works is also based on an implicit risk analysis considering three aspects: extra nuisance for citizens and related imago of the municipality due to extra excavation works, higher costs due to extra excavation works and road reconstruction, and extra traffic disruption due to extra excavation works.

The implicit risk analyses, both for renewal need and potential cooperation, are usually made by one or two sewer system managers within a municipality. The risk judgment can differ per person judging the risk and over time. This is caused by the absence of quantitative variables and a reference model for these risks.

Apart from pipe age, pipe status and cooperation with other public works, many other information sources are used for deciding upon renewal as indicated by the interviewees and described in the municipal sewerage plans. Examples are municipal water management strategy, citizens' complaints and maintenance reports. Although these information sources are relevant to base renewal decisions on, a uniform and structured procedure for this is absent.

The identified information sources from the interviews do not differ per organizational level. The interviewees often indicated that in practice, working activities per organizational level overlap to a large part. In fact, what is seen as the strategic level of sewer asset management, are in practice tactical tasks.

4. CONCLUSIONS AND RECOMMENDATIONS

The goal of this study was to assess the availability and use of information in decision-making for sewer system renewal in the Netherlands. The control paradigm of De Leeuw was chosen as a reference model to evaluate sewer asset management, because this model formed the basis for developing it in the Netherlands. Based on the preconditions for effective control, it is concluded that current sewer asset management in the Netherlands is ineffective, although service availability is good.

Precondition one: an evaluation mechanism for control actions or fulfillment of goals is absent. Next to that, the influence of intuition hampers justification, accountability and repetition of decisions, preventing evaluation. Precondition two: a model of the controlled system for predicting the effect of control actions is absent. Although hydraulic modeling is often applied, no mechanism is available to predict the effect of various control actions. Precondition three: information of the system and environment is collected, but a structured and uniform procedure to transform information into control actions is absent. The main question is what information is needed for sewer asset management.

For further organizational analysis of sewer asset management, it is recommended to compare De Leeuw's control paradigm with other theories of organizational configuration. It is recommended to implement evaluation mechanisms in order to evaluate control actions, fulfillment of goals and cost-efficiency of control. Next to that, sewer system managers need a critical attitude to judge the relevancy and quality of information.

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