LIBRA : prioritizing investments in combined sewer systems

LIBRA : planifier les investissements pour les systèmes d'assainissement unitaires

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RESUME

Pour établir des plans d'investissements, le plus grand problème est la comparaison plus ou moins objective des projets qui sont souvent d'une nature complètement différente. LIBRA est un instrument qui est développé pour évaluer des projets d'assainissement concernant leur impact. Cet instrument est basé sur le comportement hydrologique des systèmes d'assainissement (unitaires) en utilisant les résultats des simulations continus et à long terme avec un logiciel simplifié. LIBRA utilise l'information et les mesures disponibles et des paramètres faciles à estimer. Tous les résultats sont exprimés dans la même unité finale. L'utilisation pratique de LIBRA pendant deux années de plans d'investissements prouve qu'il est possible de comparer l'impact de projets complètement différents d'une manière standardisée et d'établir des classifications réalistes comme aide à la décision qui soutient la stratégie de l'agence environnementale.

ABSTRACT

When making up investment plans for urban drainage and waste water treatment, a major problem is the comparison of projects of completely different kind and this in a more or less objective way. The LIBRA tool has been built for the evaluation of projects on urban drainage and treatment with respect to their impact. This tool is based on the hydrological behaviour of (combined) sewer systems using the results of continuous long term simulations with a reservoir model. LIBRA uses readily available data and measurements. The required data for the analysis of projects are general parameters that can relatively easily be estimated. All results are expressed in the same final unit. The practical use of this tool during two years of investment planning shows that it is possible to compare the impact of completely different types of projects in an standardised way and to make up realistic rankings as decision support for investment plans, which support the policy of the environmental agency.

KEYWORDS

combined sewer overflows, investments, optimisation, reservoir model, source control, waste water treatment

1 INTRODUCTION

As Belgium is a federal state the regions (i.e. Flanders, Wallonia, Brussels) are fully responsible for all aspects concerning the environment. Concerning waste water treatment in Flanders, one has to distinguish between the local and the supra-local level. The local level is responsible for the collection of the discharges of the households in sewers. The supra-local level is responsible for the transport of the collected wastewater via main sewers and for the treatment of the wastewater at the Urban Waste Water Treatment Plants (UWWTP's). Both for the local and the supra-local level substantial investments are needed in new infrastructure and in the optimization of existing infrastructure in the context of the Water Framework Directive. The major part of the sewer systems in Flanders are combined sewer systems, although the last decades priority is given to source control and separate sewer systems.

2 DEFINITION OF THE PROBLEM

Concerning the Flemish Region, the Flemish Environment Agency (VMM) is responsible for drawing up the investment plans for the supra-local level and for the assignment of subsidies to the local authorities. A major problem in this task is how to compare investments with a very different nature.

For example how can we compare :

- a project that aims to raise the capacity of a UWWTP
- a project that aims to build extra storage capacity in the collecting system
- a project that aims to disconnect non-polluted waters (e.g. runoff water from fields or drainages) from the sewerage
- a project that aims to connect the households formerly treated by septic tanks or other individual treatment
- …

In order to draw up the most effective investment plan a balanced comparison is crucial. Moreover, this comparison must be based on readily available data and measurements and the results must be expressed in the same units. A similar approach was already worked out for the evaluation of the exploitation of supra-local transport and treatment of combined waste water using performance indicators based on readily available measurements and expressing the results in untreated Inhabitant Equivalents (Vaes et al., 2005).

3 THE SOLUTION

To solve this problem the Flemish Environment Agency has developed a tool called LIBRA (Latin for balance).

The preconditions for this tool were :

- Stimulating remediation at the source of the problem instead of end-of-pipe
- Taylor-made approach for each collecting system (no strong generalisations)
- Take Combined Sewer Overflows (CSO's) into account in a balanced way

The LIBRA tool is based on the reservoir model Remuli (developed at the K.U.Leuven) (figure 1) (Vaes, 1999) which takes into account :

- The storage capacity
- The capacity of the UWWTP
- The connected load (inhabitants and industrial)
- The connected surface (runoff)
- The measured dry weather flow (Vaes et al., 2005)
- The parameters of the project

The scientific foundations of the model were worked out by HydroScan, based on the reservoir model Remuli (Vaes, 1999). This is a conceptual model that runs with continuous long term simulations (100 years). In this way a good estimation of the overall performance of the CSO's on the long term can be assessed as well as the variation of inflow in the treatment plant.

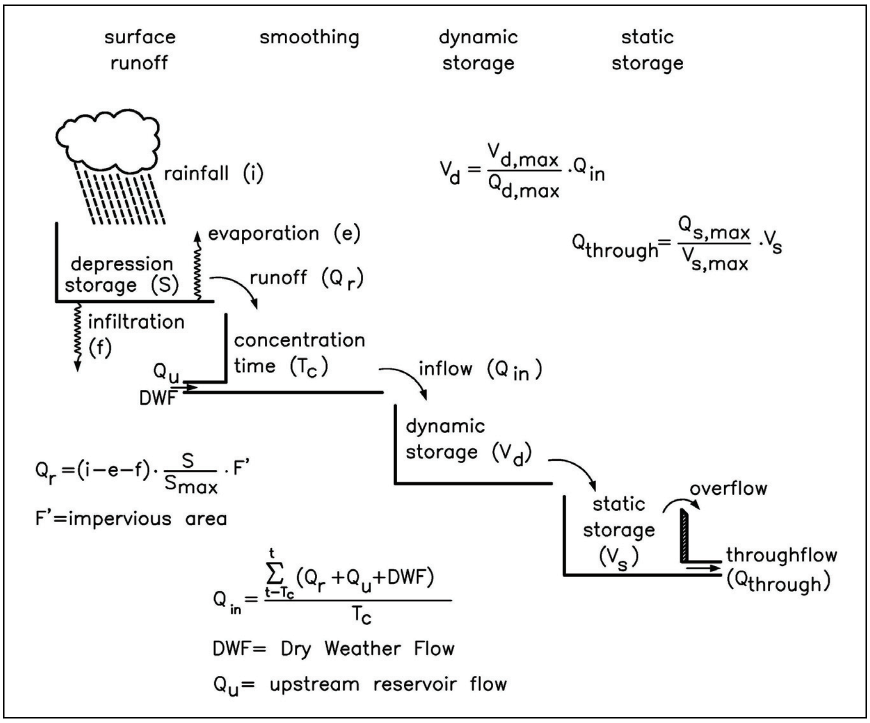

Figure 1 : Schematic overview of the Remuli modelling system (Vaes, 1999).

With this Remuli model the effect of different measures on the overflow emissions (frequency, volume) and on the treated volumes can be assessed for a wide range of wet weather conditions. Figure 2 represents the variation of overflow frequencies for a wide range of specific storage volumes and overcapacities (= (capacity – DWA) / contributing area), which are the results of the Remuli model. A similar relationship is used for the overflow volumes (figure 3).

The LIBRA tool makes a volume balance for the system before and after a project based on the simulations of the reservoir model. The results are expressed in Inhabitant Equivalents (IE) that on the one side go to the treatment plant and on the other hand are spilled at the CSO's based on the ratio of volumes. An Inhabitant Equivalent corresponds to the waste water production of one person per year. Also the effect at the input side is taken into account, e.g. how much more pollution is taken up by the system in order to transport it to the treatment plant, how much rainfall runoff is disconnected through source control measures, ... This input aspect is important to support the source control strategy of the Flemish government.

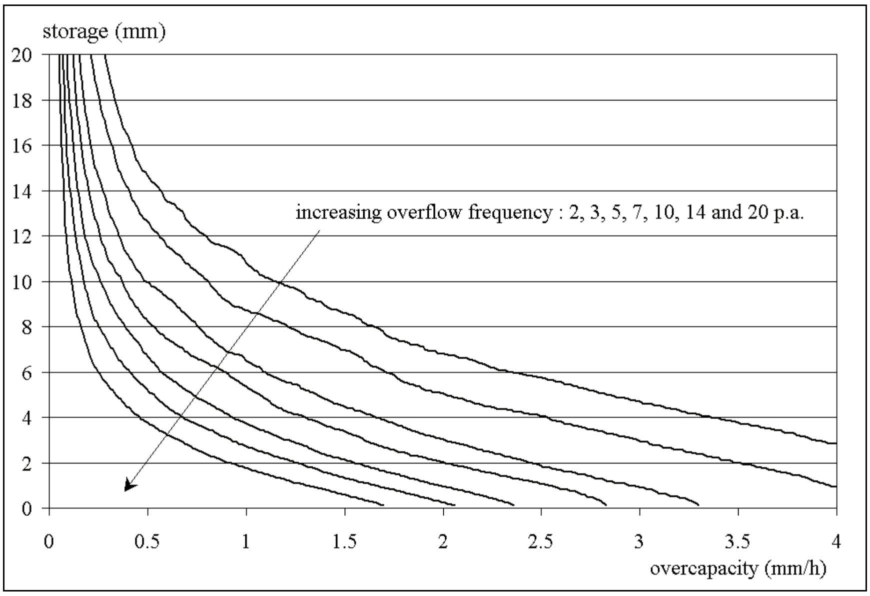

Figure 2 : Overflow frequencies calculated with a single reservoir model with a constant throughflow and a concentration time of 60 minutes for the Belgian rainfall (Vaes, 1999).

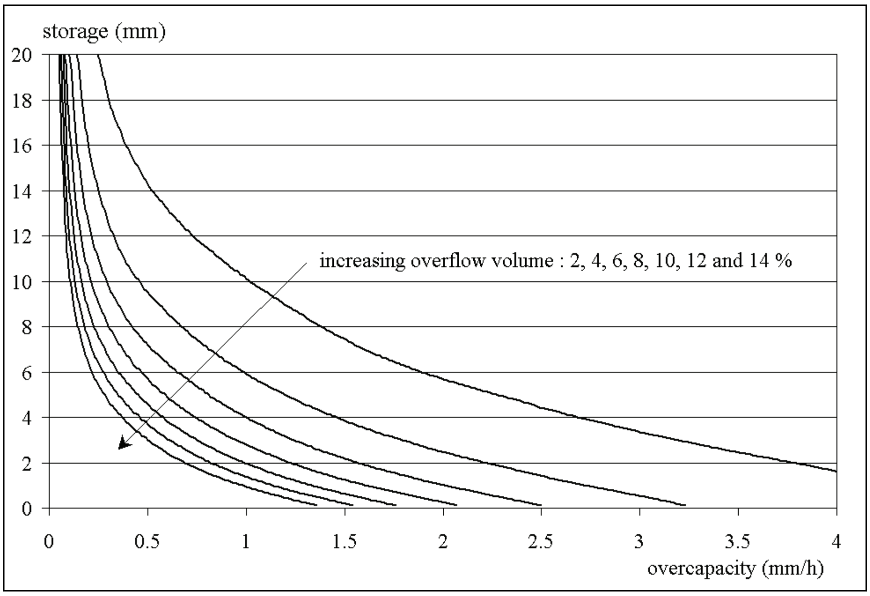

Figure 3 : Overflow volumes calculated with a single reservoir model with a constant throughflow and a concentration time of 60 minutes for the Belgian rainfall (Vaes, 1999).

By using this model, it is possible to compare projects of different type in different drainage systems in a balanced way. The possible projects that can be evaluated are :

- Extra pollutant loads connected (households or industrial)
- Disconnection of infiltration flow or pervious areas
- Disconnection of impervious area (source control, separate systems)
- Additional UWWTP capacity (treatment plant upgrade)
- Additional storage in the combined sewer system (new pipes or storage tanks)

In figure 4 an example of using the LIBRA tool is shown.

Additional to the basic calculation of the mean impact, an extra tool was incorporated to estimate also the uncertainty on the result. For the main input parameter a range can be specified in which the mean value is situated. Using Monte Carlo simulations the uncertainty on the result can be calculated. If this is done for different input parameters separately, the most sensitive input parameters can be determined and a better assessment of the mean value and the possible variation of this input parameter can be carried out in order to make the final result less uncertain.

LIBRA : Calculation tool for the assessment of the Inhabitant Equivalent of a project

project name		
number UWWTP	**166**	
name treatment area	**Lier**	

general parameters	mean values	
runoff coefficient impervious	0.8	
runoff coefficient pervious	0.3	
reduction pervious to impervious	0.375	
theoretical impervious area	**85**	m²/IE
mean rainfall	760	mm/year
theoretical dry weather flow	150	l/day/IE
system storage	**7.0**	mm

parameters for the UWWTP and area

theoretical values		
number of inhabitants	**25250**	inhabitants
industrial discharge	**0**	m³/day
industrial load	**0**	IE
measured values		
real dry weather flow	**12000**	m³/day
capacity UWWTP	**25000**	m³/day
equivalent impervious area	**0**	m²
storage	**0**	m³
calculated values		
theoretical dry weather flow	3788	m³/day
estimated equivalent impervious area	2146250	m²
estimated overcapacity	0.252	mm/h
specific storage	7.0	mm
correction overflow	79.85%	
specific throughflow	95.38%	
specific overflow volume	20.15%	
estimated overflow frequency	21.1	days

project parameters

How much load is theoretically extra connected ?	2500	inhabitants
How much parasitic flow (e.g. infiltration) is disconnected ?	0	m³/day
How much impervious area is disconnected ?	0	m²
How much pervious area is disconnected ?	0	m²
How much extra throughflow capacity is created ?	3500	m³/day
How much extra storage is build ?	1500	m³

calculations for the project

predicted dry weather flow	12375	m³/day	103.13%
predicted equivalent impervious area	2358750	m²	109.90%
predicted overcapacity	0.285	mm/h	112.86%
predicted mean storage	7.0000	mm	100.00%
predicted correction factor overflow	81.46%		102.02%
predicted throughflow	95.53%		100.17%
predicted specific overflow volume	18.54%		91.99%
predicted overflow frequency	19.6	days	92.54%

global result

Calculated equivalent inhabitants for the project

relative effect on the input	**1200**	IE	4.75%
effect on throughflow to UWWTP	**2428**	IE	9.62%
effect on overflow	**-56**	IE	-0.22%
total Inhabitant Equivalent	**3572**	IE	14.15%

Figure 4 : Example of the use of the LIBRA tool.

4 THE RESULTS

4.1 Theoretical test

Before using this methodology in drawing up the investment plans, sensitivity tests were carried out to have a decent view on the behaviour and extrapolation limits of the model. From these tests we have learned that LIBRA meets the initial preconditions and the results correspond with the expectations and the policy.

4.2 Practical use

This model has, until now, been used as assistance tool in two supra-local annual investment plans for the Flemish Region (approximately 150 projects were calculated). For all the projects that are applied for the impact is calculated and the projects are ranked. Apart from the results of the LIBRA model, practical considerations (combination with projects of other departments, social and economical impact, …) also play a role in the drawing up of the investment programme.

Some examples of practical application (the results are expressed in IE and as a percentage of the global number of IE connected to this UWWTP) :

- Project 1 : extra connections + upgrade UWWTP
  - extension of UWWTP with 3500 m^3/day
  - extra load of 2500 inhabitants connected
  - 1500 m^3 extra storage in new pipes

  Global result (see also figure 4) :

relative effect on the input	**1200**	IE	4.75%
effect on throughflow to UWWTP	**2428**	IE	9.62%
effect on overflow	**-56**	IE	-0.22%
total Inhabitant Equivalent	**3572**	IE	14.15%

- Project 2 : separate system in stead of combined
  - extra load of 100 inhabitants connected
  - 1000 m^3/day parasitic flow disconnected
  - 10 ha impervious area disconnected
  - decrease of storage in the pipes with 100 m^3

  Global result (same basic data as for project 1 in figure 4) :

relative effect on the input	**1936**	IE	7.67%
effect on throughflow to UWWTP	**197**	IE	0.78%
effect on overflow	**569**	IE	2.25%
total Inhabitant Equivalent	**2702**	IE	10.70%

The first subresult “relative effect on the input” concerns the impact on the input to the drainage system, e.g. source control measures. The second subresult “effect on throughflow” concerns the difference in treated volumes in the UWWTP. The third subresult “effect on overflow” concerns the difference in spilled volumes at the CSO’s.

5 CONCLUSIONS

The LIBRA tool has been built for the evaluation of projects with respect to their impact. This tool is based on the hydrological behaviour of (combined) sewer systems using the results of continuous long term simulations with the reservoir model Remuli. The input parameters for the tool are readily available data and measurements and the results are for all types of projects expressed in the same units, i.e. Inhabitant Equivalents. This tool makes it possible to compare the impact of completely different types of projects and to make up rankings as decision support for investment plans.

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