



HAL
open science

Application of a guideline document for sewer system real time control

V. Erbe, M. Schütze, U. Haas

► To cite this version:

V. Erbe, M. Schütze, U. Haas. Application of a guideline document for sewer system real time control. NO-VATECH 2007 - 6ème Conférence sur les techniques et stratégies durables pour la gestion des eaux urbaines par temps de pluie / 6th International Conference on sustainable techniques and strategies for urban water management, Jun 2007, Lyon, France. pp.761-768. <hal-03290742>

HAL Id: hal-03290742

<https://hal.science/hal-03290742v1>

Submitted on 19 Jul 2021

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



HAL Authorization

Application of a guideline document for sewer system real time control

Application d'un guide pour la gestion en temps réel des réseaux d'assainissement

Erbe V. *, Schütze M. **, Haas U. ***

* Wupperverband, Untere Lichtenplatzer Str. 100, D-42289 Wuppertal, Germany (erb@wupperverband.de)

** ifak e. V. Magdeburg, Steinfeldstr. 3, D-39179 Barleben, Germany

*** InfraConsult GmbH, Schaiblestrasse 1, D-70499 Stuttgart, Germany

RESUME

Récemment, le groupe de travail « Contrôle en temps réel » de l'association allemande pour l'eau, l'assainissement et les déchets (DWA) a élaboré une recommandation - bientôt disponible en anglais - sur la planification des systèmes de contrôle en temps réel pour les bassins versants urbains (DWA M180). Cet article donne les grandes lignes de cette recommandation et illustre son application à la planification d'un système CTR pour le réseau d'égout de Reutlingen Nord, (RFA). La procédure par étapes permet d'identifier le potentiel de CTR d'un réseau donné d'assainissement et de concevoir un système CTR. Si ce potentiel est faible, on peut rapidement mettre fin à la procédure, ce qui évite des travaux inutiles sur des systèmes sans potentiel CTR. Les auteurs espèrent que la recommandation M180 facilitera le travail des ingénieurs et permettra de surmonter les réticences à l'égard des systèmes CTR.

ABSTRACT

Recently, the Working Group "Real time control" of the German Association for Water, Wastewater and Waste (DWA, formerly: ATV-DVWK)¹ has prepared a guideline document on planning of real time control (RTC) systems for urban drainage catchments (DWA M180). It will soon also be available in English. This paper outlines the guideline document and illustrates its application to the planning of an RTC system for the sewer network of Reutlingen Nord/Germany. The proposed step-by-step procedure allows to establish the RTC potential of a given sewer network and to design a RTC system. If the RTC potential of the given system is low, the procedure can be terminated early, thus ensuring that no unnecessary efforts are being spent on systems without RTC potential. The authors hope that the M180 guideline document will assist practising engineers and help to overcome reluctance against RTC systems.

KEYWORDS

Model based control, real time control, sewer system, stormwater management, urban runoff, urban wastewater system.

¹ The contributions of all members of the working group to the preparation of the guideline document are acknowledged. Besides the authors of this contribution, these include J. Broll-Bickhardt, D. Gatke, D. Kreutz, A. Meßmer, M. Scheer, B. Schumacher, M. Weilandt, M. Weyand, W. Schilling

1 INTRODUCTION

Numerous studies and practical applications have proven that real time control (RTC) of urban drainage systems can be a means of achieving at least one of the two fundamental objectives in urban wastewater management – improved performance (e.g. lower overflow volumes and loads) of wastewater systems on the one hand, and reducing capital and operational expenditure for such systems on the other hand.

Despite this benefit and despite the fact that there are at least 30 RTC installations in Germany alone, RTC does still not represent an every-day technology, and guidelines in many countries do not make provisions for systems operated under RTC. The threshold for urban drainage engineers often seems to be too high and the risks too great to endeavour on such a route. In order to overcome this barrier, the German DWA Working Group on RTC has prepared a guideline document (DWA-M 180, 2005), which presents a step-by-step procedure towards planning and implementation of RTC for a given urban drainage system. The procedure starts with basic considerations and has milestones, following the principle to avoid crucial (i.e. expensive) decisions unless they are fully justified. The guideline document also includes a planning tool on CD, named PASST (“Planning Aid for Sewer System Real Time Control”) (Schütze et al., 2004b).

1.1 RTC – a potential alternative to other measures

Real time control is usually neither considered nor applied for its own sake, but as an option of improved management of water resources. In engineering practice, for example when setting up a Master Plan, usually several alternative drainage solutions are being considered. These may include, but are not limited to, construction and redesign of sewer infrastructure, disconnection of parts of the catchment and similar measures to implement source control (Best Management Practices). However, any of such measures usually aims at one or several of the following objectives:

- Reduction of (receiving water) pollution
- Ensuring hygienic conditions, avoiding flooding within the catchment
- Minimisation of capital expenditure
- Optimised operation of the wastewater system, minimisation of operational expenditure

Comprehensive introductions into the fundamental concepts of RTC are given, for example, by Schilling (1989, 1994) and by Schütze *et al.* (2004a).

2 PLANNING PROCEDURE

The DWA-M 180 guideline document provides guidance to the engineer in order to enable him to assess the potential of real time control. Furthermore, it gives valuable advice for the various stages of the planning and implementation process. Whilst the document puts its main emphasis on technological-environmental aspects, it also addresses legal and financial issues. The proposed procedure consists of three main steps, which are shown in Figure 1.

2.1 Step 1 - Initial considerations

In the first step, the objectives of the urban drainage system under study are specified. This may sound trivial, but – as practice shows – this task may involve numerous discussions with the company operating the system, relating to each other environmental objectives, financial objectives and the consenting procedure. Often, a multitude of objectives will have to be considered in the evaluation whether real time

control is suitable for a given site. The evaluation is based on a point scoring table (contained also within PASST) that constitutes the first milestone of the procedure.

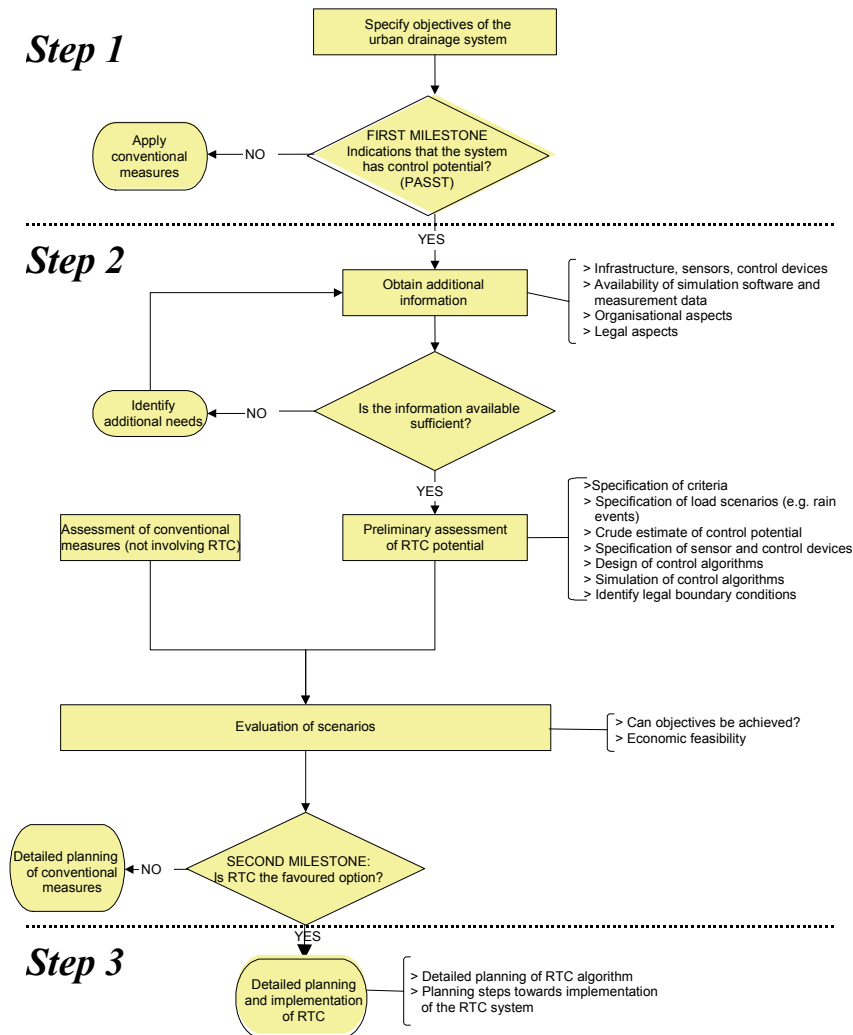


Figure 1. Flow chart of RTC planning procedure

2.2 Step 2 - Preliminary analysis

At this stage, some more information on the case study is required: Information should be collected on the detailed network layout, catchment data, existing sensor and control equipment, availability of simulation models for the given system, and the organizational, legal and regulatory framework. Discussions with the operational staff will also be of great importance here, since they often have expertise with the system

which might not be documented in written form. Furthermore, involvement of the operational staff will also increase the acceptance of any RTC system because it has to manage it in future. If any information required for the subsequent steps is missing, it should be collected at this stage. The description of the current state of the drainage system and of its current performance will also be invaluable when comparing any future operational scenarios against the present state. Core of this preliminary analysis is a preliminary simulation study. After an initial check on the potential for control, obtained from an analysis of the behaviour of the existing system or using some indices and doing some simple mass balancing, a simulation study should be carried out.

2.3 Step 3 - Detailed planning of the RTC system and its implementation

If the evaluation of various scenarios has resulted in RTC being the favoured option, the next step will consist in detailed planning of the control system. Due to different dimensions and boundary conditions within each particular system, the guideline document can provide only some general recommendations for this step. Subsequent steps refer in particular to the following aspects:

- Step 3.1. Detailed planning of control infrastructure
- Step 3.2. Detailed design of the control algorithm
- Step 3.3. Preparations for obtaining consent by the governmental authorities
- Step 3.4. Risk and failure analysis

Furthermore, the appendix of the guideline document summarises the planning steps in a table, listing 32 detailed steps of the RTC planning procedure, which can be used in the planning and procurement stages of an RTC project. Also some more details on some of the aspects mentioned (in particular on organisational aspects, sensor and control equipment, quality of measurement data, calibration of sewer system models, operation of pumps) are contained in the appendix of the guideline document.

3 CASE STUDY CITY OF REUTLINGEN

This chapter illustrates the application of the M180 guideline document to planning of an RTC system for the Northern part of the city of Reutlingen/Germany. Reutlingen is situated in a hilly region 40 km south of Stuttgart. Its sewer system (mainly combined), feeding the Reutlingen Nord WWTP, serves a population equivalent of 80000.

According to German legislation, discharge consents for combined sewer systems are based on annual pollutant loads discharged. Consents have to be renewed every 15 or 20 years. In the current application for consent, also options for improved operation of the sewer system – such as RTC – are being included. Therefore, RTC is considered here as one of the potential options.

3.1 Step 1 - Initial considerations

Several villages are connected by two main collectors to the Reutlingen Nord WWTP. Due to the large extent of the system, not only long flow times, but also non-uniform distribution of rainfall are to be taken into account when analysing and improving the system.

The sewer network has 17 overflows and 11 overflow structures with storage, which discharge into 7 highly sensitive receiving water bodies (Figure 2). Continuation flows (and, thus, overflow discharges) can be controlled by throttle devices.

	Criterion	Evaluation		
A.	Catchment	Scores (value in brackets)		
A.1	Catchment area (Flow length in the main collector)	long > 5 km (2)	medium (1) ●	short < 1 km (0)
A.2	Differences between current and planned development of the area	large (2) ●	small (1)	none (0)
B.	Wastewater production	Scores		
B.1	Areas with increased pollution of surface runoff	Several (2)	1-2 (1) ●	none (0)
B.2	Variability in time and space of wastewater production (e.g. producers of heavily polluted wastewater, connections from separate systems)	high (2)	medium (1)	none (0) ●
C.	Sewer system	Scores		
C.1	Number of existing control devices (e.g. pumps, slides, weirs)	Several (4)	1-2 (2)	None (0) ●
C.2	Slope of trunk sewers	flat < 0,2 % (4)	medium (2) ●	steep > 0,5 % (0)
C.3	Capable loops in the sewer system	Several (4)	1-2 (2)	None (0) ●
C.4	Number of existing storage tanks (tanks and storage pipes (? 50 m³))	> 4 (4) ●	1 - 4 (2)	0 (0)
C.5	Number of discharge devices	> 6 (4) ●	2 - 6 (2)	< 2 (0)
C.6	Total storage volume (tanks and storage pipes)	> 5000 m³ (4) ●	2000 – 5000 m³ (2)	< 2000 m³ (0)
C.7	Specific storage volume (= total storage volume related to impervious area)	> 40 m³/ha (4)	20 – 40 m³/ha (2) ●	< 20 m³/ha (0)
C.8	Number of collectors to the WWTP	> 2 (3)	2 (1) ●	1 (0)
D.	Operational system behaviour	Scores		
D.1	Local flood areas	Several (2)	1-2 (1)	None (0) ●
D.2	Number of non-uniformly used tanks	> 1 (4)	1 (2) ●	None (0)
D.3	Non-uniform discharge behaviour	Significant (4)	Medium (2) ●	Insignificant (0)
E.	Receiving water	Scores		
E.1	Local differences in hydraulic capacity	Strong (4) ●	Medium (2)	None (0)
E.2	Local differences of load capacity (e.g. swimming, fish farming, protected areas)	Significant (4)	Medium (2) ●	Insignificant (0)
E.3	Sensitivity of the receiving water body	Very sensitive (2) ●		Less sensitive (0)
F.	Wastewater treatment plant (WWTP)	Scores		
F.1	Admissible combined wastewater inflow (*)	$> 1,0 f_{s,OM} Q_{s,aM} + Q_{F,aM}$ (3) ●	$> f_{s,OM} Q_{s,aM} + Q_{F,aM}$ (1)	$< f_{s,OM} Q_{s,aM} + Q_{F,aM}$ (0)
F.2	Sensitivity of WWTP to hydraulic or pollutant peaks	Very sensitive (2)		Less sensitive (0) ●

(*) The values of the combined wastewater inflow and the appropriate factor $f_{s,OM}$ are related to the ATV-DVWK guidelines A 198 (ATV-DVWK A 198, 2003)

Scores: 0 - 24: probably not suitable for RTC

25 - 35: probably suitable for RTC

> 35: very suitable for RTC ●

Table 1 : Scoring table for the assessment of RTC potential of the Reutlingen Nord sewer system (see Schütze et al., 2004b, for details on the individual items)

In order to establish whether the operation of this system could be improved by application of RTC, the scoring table of PASST was used in a first step of the evaluation of the RTC potential of the Reutlingen Nord sewer system. Data already available from the Master Plan could be used here.

3.2 Step 2 - Preliminary analysis

With a total score of 36, the case study appears to be very suitable for RTC. Therefore, a more detailed study of the system was carried out. Particular emphasis was laid on the aspect whether by application of RTC the discharges into the highly sensitive receiving water bodies could be reduced, without however jeopardizing this effect by increased discharges into other water bodies (which would also be achievable by static measures)

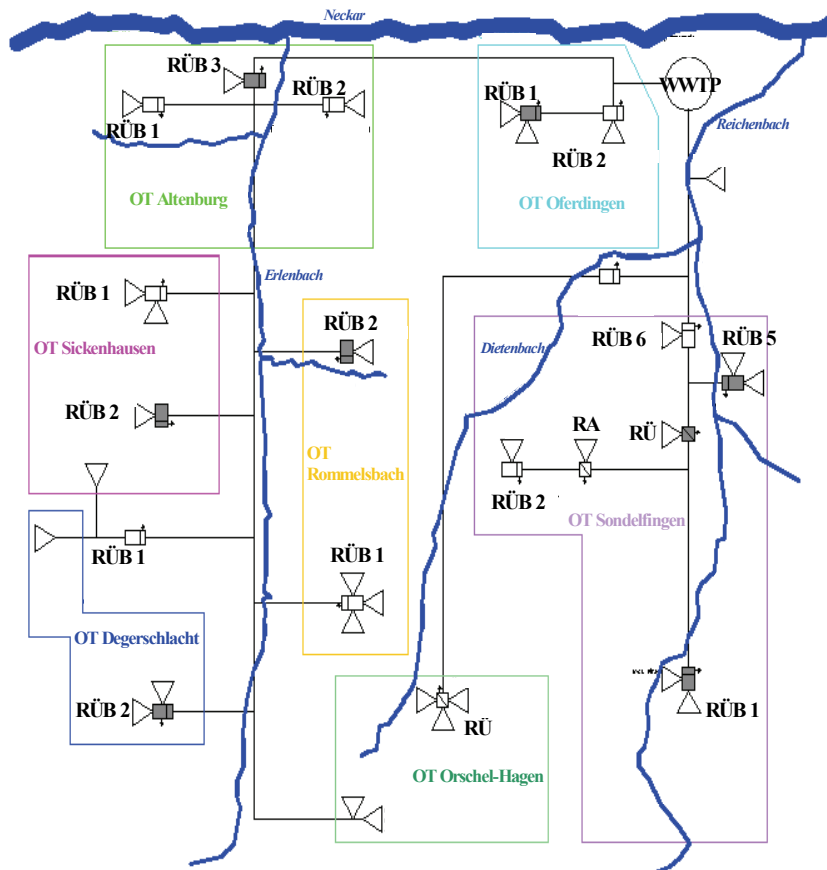


Figure 2: Scheme of the Reutlingen Nord sewer system with seven receiving water bodies

Figure 2 illustrates the system with its seven receiving water bodies. Any solution to be proposed would have to consider the following two aspects:

- The network has a large extent and is thus characterised by non-uniform distribution of rainfall.
- Inflow to the WWTP can be increased (temporarily)

For the sake of simplicity, only the existing control devices were considered, whilst the available in-sewer storage volume has been neglected in this study, thus providing additional safety margins.

Since the analysis was based on an earlier consent (already given) for a traditional way of discharge (with static settings), for the first step only qualitative (non-quantitative) results were sufficient, thus facilitating the use of the available simulation models. A selection of individual rainfall events (varying by volume, intensity, geographical extent and spatial distribution) has been used for the subsequent phases of the analysis.

When establishing the RTC potential of the Reutlingen Nord system in detail, those storage tanks which are overflowing frequently (and which are, thus, already fully utilized) were not taken into account.

Within the sewer network, two main parts (A and B) could be identified, having different patterns and distribution of rainfall. A simple control strategy, coordinating two incoming flows, has been set up as follows:

Increase flows from Region A towards the WWTP, whenever Region B receives little (or no) rainfall, and vice versa.

Long flow times within the Reutlingen Nord system may lead to flows arriving at the WWTP to be in excess of the maximum permissible inflow of the WWTP. However, short time increase of the inflow to the WWTP (possible at this case study site) alleviate this situation. This strategy can be easily implemented. Simulations proved that it is highly efficient, reducing the discharge load by about 8 %. It should be pointed out that this benefit can be achieved by a very simple control strategy, without any need for capital expenditure for structures or control devices. Furthermore, the simplicity of this strategy also proves beneficial for its implementation (both by the technical equipment as well as by the operating staff). Since this simple global control system can be switched to static mode at any time, an in-depth analysis of failure scenarios did not show to be necessary for this case study.

3.3 Step 3 - Detailed planning of the RTC system

Currently, the municipality of Reutlingen is modernising the technical equipment as a routine measure. Here, also the results of the previous steps are being considered. Additional planning steps with regard to RTC are to be expected in the coming year.

4 CONCLUSIONS

Real time control introduces a non-traditional operational approach (i.e. manipulating flows actively rather than accepting passively what happens) in urban drainage. Many urban drainage engineers back off from embarking on RTC and rather favour traditional solutions to solving flooding and pollution problems connected to combined sewer systems. However, RTC has frequently shown that it solves these problems, particularly those connected to combined sewer overflows in a very cost-efficient manner. In order to promote RTC in urban drainage and to lower the threshold for getting started accepting the approach, the German DWA Working Group for RTC has devised a procedure to analyse the potential of RTC.

The procedure is carried out in steps which are separated by milestones for making crucial decisions. An important feature is that any urban drainage engineer ought to be able to carry out Step 1 ("initial considerations") in-house because this stage is simply based on his operational knowledge about his own drainage system. Efforts for carrying out Step 1 are very limited (in-house work). Only if the case shows sufficient potential for applying RTC, Step 2 ("preliminary analysis") is carried out, typically in collaboration with a consultant and with specialised external reviewers. Step 2 reveals whether RTC is viable at the first place and, if so, what level of RTC should be aimed at. Although most challenging from an analysis point of view, the costs for Step 2 are still comparatively low. If RTC shows to be a feasible and beneficial option for the urban drainage system under study, Step 3 ("detailed planning") is carried out comprising of detailed design.

The case study of Reutlingen Nord presented in this paper demonstrates that in some cases, even with little effort and simple control strategies, RTC can lead to improved performance of urban drainage system. Also external boundary conditions (such as non-uniform distribution of rainfall in larger systems) can be utilised in a beneficial way. The authors hope that RTC as a means to improved operation of urban drainage system using existing infrastructure will find wider application and that the new M180 guideline document will assist the drainage engineer in the related planning steps.

LIST OF REFERENCES

- ATV A198 (2003). ATV-DVWK. Vereinheitlichung und Herleitung von Bemessungswerten für Abwasseranlagen. Gesellschaft zur Förderung der Abwassertechnik (GFA), St. Augustin
- DWA - Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e. V. (2005): Handlungsrahmen zur Planung von Abflusssteuerung in Kanalnetzen; Merkblatt DWA-M180 (in German; its English edition will be available in spring 2007); ISBN 3-939057-02-9
- Schilling, W. (ed.) (1989). Real-Time Control of Urban Drainage Systems. The state-of-the-art. IAWPRC Task Group on Real-Time Control of Urban Drainage Systems. London
- Schilling, W. (1994). Smart sewer systems improved performance by real time control". *Eur. Water Pollution Control*. 4, 5, 24-31
- Schütze, M.; Campisano, A.; Colas, H.; Schilling, W.; Vanrolleghem, P. (2004a): Real-time control of urban wastewater systems - where do we stand today? *Journal of Hydrology*, 299, 335-348
- Schütze, M.; Erbe, V.; Haas, U.; Scheer, M.; Weyand, M. (2004b): PASST – A planning aid for sewer system real time control; 6th International Conference on Urban Drainage Modelling – UDM '04. Dresden. 15 – 17 September 2004