Aalborg University
December 1, 2006

Task C, 1st delivery: Report on monitoring program produced

Contract text to which this deliverable refers:

> Planning of monitoring program (Action C4). To ascertain that the results obtained in this project are transferable, emphasis is put on monitoring the performance of the facilities as well as monitoring the catchments creating the stormwater runoff. The facilities and catchments are therefore equipped with installations and devises, having the sole purpose to document the performance of the different treatment technologies on each site. It is therefore deemed essential that the planning of the monitoring program is an integrated part of the design and that the planning of the monitoring program act as input to the design of the facilities.

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MONITORING PROGRAM FOR ASSESSMENT OF TREATMENT PERFORMANCE OF WET PONDS
- a general approach

1. INTRODUCTION

To ascertain that the results from this LIFE-Treasure project can be transferred to design of new systems, a monitoring program will be implemented at the three facilities located in Silkeborg, Århus and Odense, Denmark. The wet ponds and corresponding catchments will therefore be equipped with installations and devices for documentation of their treatment performance.

This report will focus on the general aspects and steps important for design of a monitoring program for the assessment of treatment performance of wet detention ponds (wet ponds) receiving stormwater runoff. The following two aspects are in this respect considered central for this deliverable:

1. Which information is needed prior to the design of the monitoring program?
2. Which elements and steps are central for a monitoring procedure to be implemented?

Handling of the data from the monitoring program, e.g. in terms of chemical analysis and statistical analysis, is not a subject of this report.

In addition to the general elements and steps that will be dealt with, this report refers to the following three deliverables where several fundamental constraints and prerequisites important for monitoring are stated:

Deliverable B1: LIST OF OPERATIONAL PARAMETERS TO BE MONITORED AT EACH OF THE THREE FACILITIES.
This report lists the parameters that are considered central for the three demonstration facilities.

Deliverable B2: REPORT ON PILOT SCALE TESTS ON TECHNICAL FEASABILITY.
This report includes details of unit processes for stormwater treatment important for design of wet ponds. In particular, extended treatment is dealt with in terms of removal of pollutants in colloidal and soluble forms.

Deliverable B3: GENERAL DESIGN CRITERIA AND GUIDELINES FOR WET DETENTION PONDS.
This report specifies the scientific and technological basis that is central for design and operation of wet ponds for treatment of stormwater runoff from urban areas and roads. Design criteria and guidelines for the general performance and treatment efficiency of wet ponds are focused on.

2. GENERAL ELEMENTS OF A MONITORING PROGRAM

The objective of this deliverable is to specify in general terms which key elements and steps must be focused on when establishing a monitoring program for the assessment of treatment performance for wet ponds. Major steps to include in the monitoring program are thereby directed towards determination of catchment characteristics and parameter monitoring including which types of equipment for on-site monitoring and sampling can be used.

The more specific objective is particularly defined by the following constraint: The monitoring program must determine the treatment performance of a wet pond in terms of a process related objective. The result of the treatment processes in the pond directed to determine the actual pollutant load on the receiving water body is in this case less important. Because of that, it is crucial to design a monitoring program that can provide rather extensive and general information for a following application in case of new wet ponds that operate under different external conditions and in case of a different pond layout and construction. Flexibility in the design of the monitoring system is central taking into account the fact that stormwater runoff is subject to a considerable variability in both flow and pollutant transport.

Prior to the design of a monitoring program, a number of theoretical, empirical and practical aspects must be considered. Particularly, such considerations relate to:

1. *The objective*
   The objective of the monitoring program in question, particularly the extent and details required.
2. *The hydraulics and the water quality*
   The hydraulics and the water quality of the flows are central in any monitoring program. The hydraulics is important in terms of both magnitude and variability. Furthermore, the selection of parameters for sampling of the flows, the level of concentrations and the variability will determine details of the monitoring program.
3. *Additional monitoring*
   Additional monitoring of the system and its surroundings take place both continuously and periodically. Results from this type of monitoring can provide additional information on the performance of the system (sediment quality; plant and animal life). Additional monitoring may also state which external impacts influence the performance of the pond, e.g. by monitoring hydrologic and climate related parameters.
4. *Practical aspects*
   Such practical aspects can be related to the specific selection of the monitoring system (equipment), manpower and technologies available for data transfer. Equipment for monitoring is in general expensive and should therefore be carefully protected. Furthermore, safe data collection and transfer is crucial and must therefore also be carefully observed.

Theoretical and practical considerations, in particular related to the first three points mentioned, are also dealt with in deliverables B1, B2 and B3.

3. SITE CHARACTERISTICS

A number of site characteristics must be considered prior to the design of the monitoring program. First of all, the size and the structure of the contributing catchment determine which capacity of the flow meters is required to record the inflow in sufficient details. Site characteristics that are particularly important to estimate are therefore:

1. The impervious area of the catchment
2. The structure of the catchment, e.g. in terms of slope and detention of the runoff
3. An estimate of periods with snowfall and snowmelt, i.e. statistics of the winter period

Furthermore, it is important to estimate the inflow of pollutants in terms of concentration levels that will determine which sampling volumes for analysis are needed.

4. PARAMETER MONITORING

A program will generally apply three major types of monitoring principles:

1. Continuous measurements by electronic monitors
2. Flow and time proportional sampling
3. Periodically performed measurements and sampling

The type of equipment needed for monitoring is highly related to the characteristics of the parameter to be monitored, cf. Section 2, particularly point No. 2 and 3. Several parameters will be extensively monitored either continuously or intermittently determined by the occurrence of the runoff events. Other parameters are monitored periodically. Therefore, the design, implementation and operation of the monitoring system are significantly influenced by the parameter characteristics. The parameters can in terms of their source and their monitoring characteristics be subdivided as follows:

1. Meteorological parameters
2. Hydraulic parameters
3. Flow related quality parameters
4. Parameters monitored in the wet pond

In the following Sections 4.1 – 4.4, these principles of monitoring will be further described.

4.1 Meteorological and climate parameters

Basically, meteorological data should be monitored at the catchment in question. However, for practical reasons they may partly originate from permanently established meteorological stations in the vicinity of the site. Examples of meteorological and climate parameters relevant in case of wet ponds are:

1. Precipitation
2. Air temperature
3. Wind speed
4. Sunlight

In most cases such parameters are monitored continuously. In case of precipitation it is semi-continuously – or intermittently – by a tipping bucket rain gauge.

4.2 Hydraulic parameters

The main hydraulic parameters are monitoring at the inlet and at the outlet of the wet pond in terms of flows. These flows must be continuously monitored as a basis for determination of mass balances for both water and pollutants. To complete this mass balance in case of extreme events, overflow must be recorded too.

A number of options exist for the monitoring of flows. In case of inlet and outlet monitoring, a full-flowing meter is in general the most reliable type. The large variability in flow that occurs at the inlet may require two flow meters covering a low and a high flow range, respectively. The overflow can be recorded by an overflow structure, e.g. of the V-notch type.

4.3 Flow related quality parameters

Flow related quality parameters are monitored either continuously or determined from analysis of water samples originating from the inflow, the outflow and the overflow. In most cases the quality parameters of the overflow will, however, be identical with those in the outflow. Examples of continuously monitored parameters are:

1. Conductivity
2. Turbidity

The non-continuous monitored parameters are in general those water quality parameters that are analyzed based on flow or time proportional sampling. Sampling therefore constitutes a very important part of a monitoring program and timing for manual collection of these samples must be planned. Because of the variability of the transport of pollutants into the pond, it is particular important to consider the time scale and frequency of sampling at the inlet.

The number of possible quality parameters analyzed for is basically legion. It is a specific task based on the objective of the monitoring program to determine the extent of this part of the program.

4.4 Parameters monitored in the wet pond

Depending on the specific objective of the monitoring program, a number of parameters can be recorded in the pond itself. Most parameters are continuously monitored. Examples of parameters for continuous monitoring are:

1. The water table
2. Temperature
3. Turbidity
4. Penetration of sunlight
5. pH
6. Dissolved oxygen

4.5 Specific parameters for monitoring

Each site has in terms of monitoring its specific characteristics determined by layout and construction details. Furthermore, the specific objective of a monitoring program will also require specific monitoring tasks. Examples of sampling and analysis to observe such specific tasks are:

1. Habitat related monitoring, e.g. sampling of plants or animals for analysis of pollutant accumulation
2. Sediment sampling for analysis of pollutant and solids accumulation
3. Flow measurements and sampling related to extended treatment facilities like filters at the outlet.
4. Sampling related to addition of chemicals for advanced treatment

5. COLLECTION AND TRANSFER OF MONITORED DATA

The data monitored at a site can be collected and transferred to the receiver in different ways with electronic procedures as the most convenient. Centralized collection of data at the site is often chosen. Transfer to the receiver of the collected data can take place with regular time intervals or be carried out manually.

It is recommended that a message to the receiver be activated in case of failure in both hardware and software.

6. FINAL COMMENTS

The ultimate goal of the monitoring program is to document the treatment performance of three wet ponds designed as demonstration facilities and located in Silkeborg, Århus and Odense, Denmark. These three facilities will in different ways treat the inflowing stormwater runoff with emphasis on pollutants in colloidal and soluble forms. The results of the monitoring program is furthermore used for comparison with other best management Practices (BMPs). In the future the results will be used in case of constructions of new wet ponds.

The monitoring program must because of different objectives and different prerequisites of stormwater treatment of the three facilities be differently designed. These details of the monitoring program are included in the following deliverable:

Deliverable B4: CONCRETE DESIGN AND OPERATIONAL SPECIFICATIONS FOR EACH OF THE THREE FACILITIES.