# Current status of management of stormwater systems and solutions in four Baltic Sea countries

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# Contents

# Summary

Stormwater filtering systems are considered as promising solutions, as they alleviate both stormwater quantity and quality problems. For that reason, many cities are going to invest in different stormwater filtration systems in the coming years. However, these structures can clean pollutants from stormwater only when correctly planned, constructed, and maintained. Many municipalities lack experience and knowledge on the life cycle management and practical realization of stormwater filtering systems; thus, there is a risk that a significant part of the newly constructed systems will not function as expected. In this report, the status of stormwater filtering structures' lifecycle management in Estonia, Finland, Latvia, and Sweden was introduced based on a literature review and a questionnaire targeted to municipal officers and consultants. The literature review revealed significant differences between the ways countries manage stormwater-related issues. In some cases, the methods and best management practices for stormwater management are well established; however, for some, the regulations and guidance for overall stormwater management are still completely lacking. The questionnaire results indicate a need for better communication between the different actors and recognition of the multiple benefits provided by the stormwater filtering structures. The information gained from the literature review and the questionnaire was compiled as check lists concerning the common pitfalls as well as best practices in the different phases of a stormwater filtering structure lifecycle. These lists can be used in the different phases of the life cycle of stormwater filtering structures to guarantee well-functioning high-quality structures. This study was a part of the CleanStormWater project, funded by the Interreg Central Baltic Programme.

# 1 Introduction

85 million citizens live in the catchment area of the Baltic Sea. The vast amount of people, densification of cities and the effects of climate change create a great need for developing stormwater management in municipalities and cities around the Baltic Sea. In the past, stormwater (SW) management has been focusing on controlling stormwater quantity, but the emphasis has more and more shifted to the quality management aspect.

Stormwater filtering systems are considered as promising solutions, as they alleviate both stormwater quantity and quality problems and many cities are going to invest in different stormwater filtration systems in the coming years. However, stormwater filtering systems can clean pollutants from stormwaters only when correctly planned, constructed and maintained. Many municipalities lack experience and knowledge on practical realization of such systems, thus there is a risk that a significant part of the newly constructed systems will not function as expected.

This report has been compiled as a part of the CleanStormWater project which aims to improve the stormwater management around the Baltic Sea. The project is funded by the Interreg Central Baltic program. The report aims at identifying the most common challenges, as well as best practices in implementation of stormwater filtering systems in Estonia, Finland, Latvia, and Sweden. This information has been used as a basis for developing check lists for sustainable stormwater filtering systems, including a set of concrete recommendations and instructions for ensuring quality at each step of the stormwater filter life cycle. The literature review of the practices in planning, contracting, constructing, and maintaining SW filter structures in the participating countries was complemented with a questionnaire and workshops targeted at municipal officers and consultants. The status of SW filtering structures management in the CleanStormWater project countries is first described according to an executed literature study and then on the basis of gathered questionnaire answers. Finally, the most common challenges are listed, as well as best practices in the implementation of stormwater filtering systems with the information gained from the workshops in Estonia, Finland, and Latvia.

# 2

# Literature review

According to the literature review, guidance on issues related to stormwater, especially to SW filtering structures, are usually given by state or municipal authorities. Difference between the instructions and regulations can be substantial between the different actors. In this chapter the state of information and instruction given in **Estonia, Finland, Latvia**, and **Sweden** is discussed.

In **Estonia**, the national stormwater dimensioning standard EVS 848 Väliskanalisatsioonivõrk 'Sewer Systems Outside Buildings' needs to be followed, when designing SW management structures. There are also laws and regulations at the national level, where some of the SW related topics are addressed, e.g., Veeseadus 'Law for Water' (Veeseadus 2019). SW is often classified as wastewater and quality management of SW is based on wastewater regulations. However, there is a lack of handbooks or guides regarding SW management and filtering structures.

Guidance on realizing SW structures in **Finland** is based on Hulevesiopas, 'Stormwater guide'. Hulevesiopas is a comprehensive handbook addressing SW quantity and quality problems, along with hands-on guidance on how to manage those with different structural and non-structural solutions. It is used by municipalities, consultants, state authorities and many other specialists. Shorter fact sheets based on the information in Hulevesiopas have been compiled under national RT standard files (Building Information, 2020). The RT file is a source of information for the building industry regarding design, contracting, construction, repair, maintenance and building products. RT standard files are a common tool in building projects in **Finland** and are used by builders, designers, contractors and building officials. The RT files usually include standards, regulations and product files concerning the subject.

SW related national instructions in **Latvia** are based on different laws at the national level. Municipalities also have their own regulatory acts. At least 14 national laws can

be identified, which to some extent regulate the stormwater management, but no one does it directly. There are no handbooks or guides concerning especially SW related issues. The laws aim to promote sustainable management of natural resources, by ensuring development of the infrastructure, construction, operation, maintenance and management of land amelioration systems in rural/urban areas (Meliorācijas likums, 2010). They also aim at establishing a system for the protection and management of surface water and groundwater to facilitate sustainable and rational use of water resources, prevent the deterioration of water and the state of the terrestrial ecosystems and wetlands directly dependent on water, gradually reduce the emission and discharge of polluting substances into water bodies, etc. (Ūdens apsaimniekošanas likums 'Water Management law' 2002). SW is often classified as wastewater and requirements in relation to polluting refer to that. Regulations in municipal level include i.e. the regulation of use and maintenance of the hydrographic network in the city of Riga, and land use and building regulations (Rīgas pilsētas hidrogrāfiskā tīkla lietošanas un uzturēšanas noteikumi 'Terms of use and maintenance of the hydrographic network of the city of Riga' 2011).

In **Sweden**, the handbooks Avledning av dag-, drän- och spillvatten 'Drainage of urban runoff and waste water' (Svenskt Vatten, 2016) and Öppna vägdagvattenanläggningar 'Open road stormwater systems' are used among other regional guides. Öppna vägdagvattenanläggningar (Trafikverket, 2015) is a publication by the Swedish Traffic Agency. This handbook consists of information and instruction chapters, providing information about nature-based solutions in SW management. National guidelines for stormwater quality management in **Sweden** are lacking. Many municipalities require the stormwater quality to be assessed with the quality of the receiving waterbody. Based on the classification of the recipient's sensitivity, the need for purification is assessed. For example, the city of Gothenburg is using the guidelines based on the prioritized substances in accordance with the water directive, The Swedish Environmental Protection Agency's (SEPA) previous guidelines for lakes and rivers and environmental quality standards for fish and mussel water.

## 2.1 Practices in planning

### Background studies

The work to improve the quality of stormwater can be carried out at various levels: upstream work, legislation, and practical measures. Analysis and measurements of the runoff volume, research about the most likely pollutants in the area that might end up in the stormwater structures and geodetic measurements of the project area that will be under construction are the factors used for SW planning in **Estonia**. Design

of the structures and system will be carried out based on the EVS SW 848. The best management practice in **Estonian** municipalities is that project team leaders should always physically visit the site itself to attain a better understanding of it.

In **Sweden** this is executed with national instructions and proper understanding of the land use, anthropogenic activity, sedimentation, historical data (history of lakes/ recipients), ecological and chemical status in all recipients. This can include e.g., a base map of the site, pictures, a technical handbook, a stormwater catchment area, a development plan for ecosystem services, an action plan for stormwater treatment, the completion, an overview of an environmental technical survey, an environmental soil survey, estimated traffic flows, the pollution situation. (Engle et al., 2018, p. 8–19) The city of Stockholm has developed a new stormwater strategy that considers the changing climate with increased rainfall and the quality of stormwater.

If the stormwater drainage solution in **Latvia** is a part of a bigger construction or renovation project, a topographic and geotechnical (incl. hydrogeology) investigation must be carried out in accordance with the requirements specified in the construction legislation. Additional research is required depending on the location and territory of impact of the construction/renovation project. Otherwise, there are no specific institutionalized guidelines on stormwater filtering structures, except for general best international practice.

The aim in stormwater planning in **Finland** is to prevent surface flow and to manage the SW on site. The starting point of the planning is to have a clear vision of the site characteristics affecting stormwaters. The first steps should include mapping of the catchment area and dividing it into smaller sub-catchments to establish the main routes for runoff. Land use for the area affects SW planning in the current state, but also future land use stated e.g., in development plans or in local detailed plans must be taken into consideration, as it can change the catchment area significantly in the future. A soil and topography mapping will give added information about the drainage divisions, areas prone to erosion, possibilities to water infiltration and possible hazardous substances or toxins in the soil. It is also important to detect areas that are already prone to flooding and the areas which will have increased flood risk in the future if land use is altering the conditions of the area. (RT-11196, 8.)

Natural water bodies, both in the planning area and in the receiving water bodies, can be used as a part of the SW management systems, but they must also be protected against possible loading of e.g., suspended solids or hazardous substances in the SW flow. In the planning of new SW management systems, all-natural waterways should be mapped,

including surface and groundwater. Research about water quality and condition of the aquatic plants and fauna will give information about the status of the waterbodies and can be later used as a reference point. Besides the waterbodies, research on the vegetation (i.e., plant species, plant coverage and protected habitats and landscapes) is required. By using nature-based SW management structures, it is possible to restore vegetated areas, changed from the natural state. (RT-11196, 8.)

**Hydraulic dimensioning**

The dimensioning of SW management structures in Estonia is executed with the standard for calculations of stormwater flows "Sewer systems outside buildings" (EVS 848). This standard is not originally made for SW management; instead, stormwater has been bundled together with sewage dimensioning. The basic guideline is that if soil and other conditions allow, stormwater should be infiltered to the soil in the same place where the rain came down. If infiltration to the soil is not possible, then the flow should be delayed before it is directed to pipes and ditches. EVS 848:2013 also gives guidelines to dimensioning stormwater systems in terms of sizes. Rainfall frequency 30min maximum, recurring once a year, is used for SW filtering systems.

In **Finland**, the dimensioning of a stormwater filtering structure is based on the amount of runoff from a predetermined design rain or snowmelt on the design catchment (RT 89-11196, 8). Design rain is calculated with duration of the rain event, intensity and volume of the precipitation and rainfall recurrence interval. When designing SW filtering structures, the volume of the stormwater design flow depending on precipitation is used as a design criterion. SW filtering structures usually consist of depression delaying the SW flow, underground filtering media which allows the water to infiltrate through and in most cases subsurface drains convey the water out of the system. As the parts of the filter structure work differently, the dimensioning is executed in a way that will take the different characteristics into account.

**Latvian** responsible authorities (e. g. Housing and Environment Department, Traffic Department) define technical rules in compliance with the binding rules of the municipality, considering the specifics of each construction/renovation project territory. The dimensioning is done in practice using various approaches.

As the legislation covers only maximum flow calculation for storm sewers contained in the Latvian Construction Regulation LBN 223-99 "External sewerage networks", the regulating authorities, who issue design permits and technical conditions, require using the Regulation for calculation. The calculation method is based on the rational

method. Thus, the procedure contained in the Regulation for peak flow is used for the flow calculation. However, in practice, engineers use the peak flow calculation also for the runoff volume calculation. Generally, the calculated maximum flow parameter for the design rain event with the duration of the corresponding time of concentration is multiplied with the duration of the event. Such calculation assumes the total duration of the rain event double to the time of concentration, linear increase in the runoff rate, reaching the peak runoff at the time corresponding to the time of concentration and then a linear decrease of the runoff in the period equal to the time of concentration. Sometimes engineers double the volume achieved in such procedure.

The rainfall frequencies used in **Latvia** are dependent on the planner. Sometimes only the least costly solution, meeting the minimum criteria is used, but most often 1/2/5-year return period is used for sewer systems and 5-10-20-year return period for rain gardens.

Generally, in **Sweden**, the flow rate of small and medium-sized rains that transport large amounts of pollution are used as a basis for the dimensioning of SW filtering structures. According to SMHI's (Swedish Meteorological and Hydrological Institute) regional climate analysis for Stockholm County from 2015, annual precipitation is expected to increase by 20–30 percent by 2100. Extreme rainfall is also becoming more common. The maximum daily rainfall is expected to increase by 20–30 percent.

**Plants in stormwater filtering structures**

Esthetic values of different SW management structures have not been emphasized in the participating countries until the last couple of years. In many cases plants have not been used, and when used, plant species have been selected by the planner's own judgement. Nowadays nature-based solutions are promoted as a part of sustainable landscape design with capabilities to enhance water quantity and quality, biodiversity, and amenity. Recommendations for the usage of plants in SW filtering structures are published in the **Finnish** Hulevesiopas.

Plants chosen for SW filtering structures should be resistant to both drought and flooding. If the structure is located near to a high traffic area, the plants should also tolerate salts from de-icing and possible loading of hazardous substances. Different plant species ensure sustainability and enhance purification processes. (Kuntaliitto, 2012, p.217–223.) The importance of sustaining biodiversity and creating areas with economic, social, and environmental benefits should be kept in mind when choosing plants for SW filtering structures.

## 2.2 Practices in competitive bidding and construction

### Competitive bidding

Since there is a lack of experience in constructing SW filtering structures in many municipalities, there can be difficulties in clearly communicating the needs and aims of the SW filtering structures planned and how to get a structure to meet all the goals. The lack of experience can make it difficult to understand what is and what is not possible. Guidance on competitive bidding in case of SW management structures does not exist in any of the participating countries. The lowest price is the most used term in the selection of the contractor, even though the best result could be achieved, when previous achievements and other qualifications would also be considered.

### Construction phase

In the construction phase of the SW filtering structures, the technical questions are often complicated, and plans might be colliding with existing infrastructure facilities. Because of the lack of knowledge among the contractors, the execution of the SW structures can sometimes be inadequate. If the construction is not monitored by a competent person, the final structure might not work as planned.

**Estonian** law allows sanctions for contractors if the finished structure does not meet the plans. Laws give an opportunity to force a contractor that has not built according to the project plan to rebuild the construction, so that it will be according to the project plan. The municipality of Viimsi in **Estonia** also uses services of an independent construction surveillance engineer whose job is to oversee the project on site and be the spokesperson between the contractor and municipality.

In **Finnish** Hulevesiopas it is stated by the Land Use and Building Act that the party engaging in a building project shall ensure that the building is designed and constructed in accordance with building provisions and regulations and the permit granted. The party shall have the necessary competence to implement the project, as required by its difficulty, and access to qualified personnel. (Land Use and Building Act 1332/1999.) In **Estonia**, this is regulated by Ehitusseadustik 'Construction Law' (Ehitusseadustik 2015). The building control authorities are responsible of monitoring the compliance of these regulations, monitoring of the construction work itself and to give further guidance e.g., in SW related issues. (Kuntaliitto, 2012 p.35–36.) In **Finnish** SW guides, there are very few instructions for the actual construction phase of the work. Advice that SW filtering structures should be built in the latest stages of a construction work or protected

during the construction activities to prevent cumulation of solids and possible clogging, remains as the most important one (Kuntaliitto, 2012, p.186). Other preventive measures should be used to prevent the loading from construction activities.

## 2.3 Practices in monitoring and maintenance

### Operation and maintenance

Stormwater filtering structures might not be able to manage excessive flow rates caused by snowmelt and intensive rainfalls. The technology can be also perceived as expensive. Problems with planning and dimensioning of the SW filtering systems has led to concerns. Maintenance of the systems is seen as a challenge.

In **Estonia**, large projects ordered by municipalities have been realized in accordance with national dimensioning standards. Balance between cost and benefit when dimensioning new stormwater systems have caused some problems. **Estonian** dimensioning standards allow some flooding when it comes to rare heavy rains and climate change is not considered as a source for increased precipitation. Older SW management structures that have been constructed without any dimensioning or simply with materials that have been available to the constructor are sometimes problematic.

In **Finland**, finished SW filtering structures are part of the cities' or municipalities' green areas and the maintenance is left for municipal officers or maintenance companies. In some cities, maintenance manuals have been prepared for each SW structure, to meet the special maintenance needs of different sites. Regular maintenance practices advised for filtering structures contains removal of trash, dead vegetation and accumulated solids from the topsoil and maintaining permeability of the filtering layers. The best way to avoid clogging of the filter media is to prevent solids from entering the structure e.g., with a separate catch pit (RT 103006, p.23). If water can no longer filtrate through the layers, drainage pipes should be checked and flushed, and as a last option, change the filtering media. Different plant species planted in the structure need to be looked after and the vegetation mown if needed. At the latest in the management state of a new SW filtering structure, it is possible to see the suitability of the selected plants. If some species wither or otherwise fail, they need to be replaced. Usually, SW filtering structures are equipped with overflow routes to manage high discharge situations. The condition of these routes must be also checked regularly. (Kuntaliitto, 2012, p.261.)

Only monitoring regarding SW management in **Latvia** is required from companies whose activities are related to pollutant substances. In terms of stormwater in city-managed

stormwater drainage systems, there is no regular monitoring done in neither open nor closed systems. The stormwater analysis is done exceptionally in cases of suspicion of pollution occurrence.

In **Sweden** the operation and maintenance of SW management structures is often neglected. Due to lack of accessibility, most often emptying and restoration are not carried out (Viklander, 2019). A handbook by Trafikverket (2015, p.147) provides a check list for maintenance and care needed for different kind of SW management solutions.

In cold climates, topsoil of the structure can freeze partly or entirely, causing malfunctions for the water entering the system. Piling of snow on SW filtering structures can cause clogging caused by the possible trash and solids in the snow and the filtering layers can compact because of the weight. (RT 103006, p.22–23.)

# 3

# Questionnaire results

In the CleanStormWater project, a questionnaire (see appendix) on the stormwater treatment in the participating countries was prepared. The questionnaire was targeted at experts working with planning and practical realization of stormwater treatment systems (urban planners and consultants, technical and/or green infrastructure developers/ operators, landscape architects, environmental experts, real estate developers, etc.). The aim of the questionnaire was to identify the most common challenges and pitfalls, as well as best practices in the implementation of stormwater filtering systems. This information will form a basis for the development of a how-to manual on sustainable stormwater filtering systems, including a set of concrete recommendations and instructions for ensuring quality at each step of the stormwater filter life cycle. There were in total 50 respondents to this questionnaire from **Estonia, Finland, Latvia**, and **Sweden**. 54% of the respondents work as municipal officers and a third as consultants, seven of the respondents defined their working role as "other", including four project managers and two architects. Question three divided the group to persons with experience in planning, constructing, or maintaining SW filtering solution and to ones without experience. Based on this answer, the questionnaire ended for those who did not have the experience. A total of 29 persons had experience and answered the whole survey. These results are discussed in this chapter.

## 3.1 Practices in planning

Answers in the questionnaire indicate that research on the area where SW filtering structures are going to be built is usually done by mapping of the existing and future land use of the catchment area and by executing topography mapping of the catchment area. Stormwater quality analysis is carried out in only small number of cases. Hydraulic modeling, stormwater volume on existing systems and soil type were mentioned in the free text fields (Figure 1).

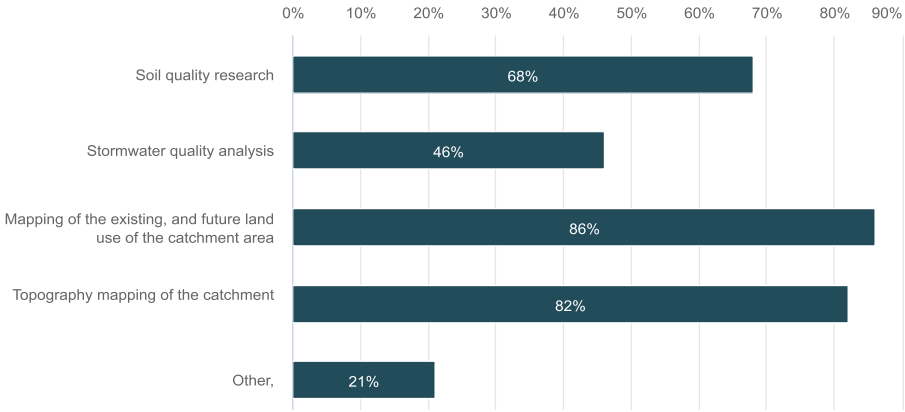


**Figure 1.**
What kind of research/investigations are made on the area where stormwater (SW) filtering structures are going to be built?

The need for better background data to improve the planning of SW filtering solutions divided the respondents in half. Finnish respondents expressed a need for better background data, but Latvians are pleased with the current situation.

Hydraulic dimensioning of the structures is mainly executed with drainage area size, drainage area runoff coefficient and predicted rainfall (Figure 2.). Respondents working as consultants seem to use more figures in the dimensioning than municipal officers. The difference can be seen especially in the use of hydraulic modeling, where 90% of the consultants, and only 31% of the municipal officers use it as a basis for the dimensioning.

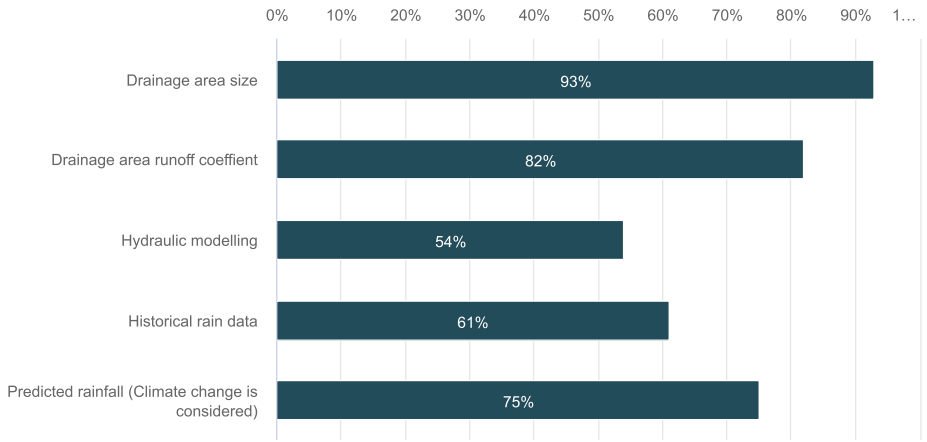


**Figure 2.**
What is used as a basis for hydraulic dimensioning?

The respondents deem the plans for SW filtering structures to consider the special characteristics of the planning area and the plans are detailed enough. 75% of all respondents use plants on the filtering systems. The plants are selected mainly by the suitability to the site growing conditions and local plants are preferred (Figure 3.).

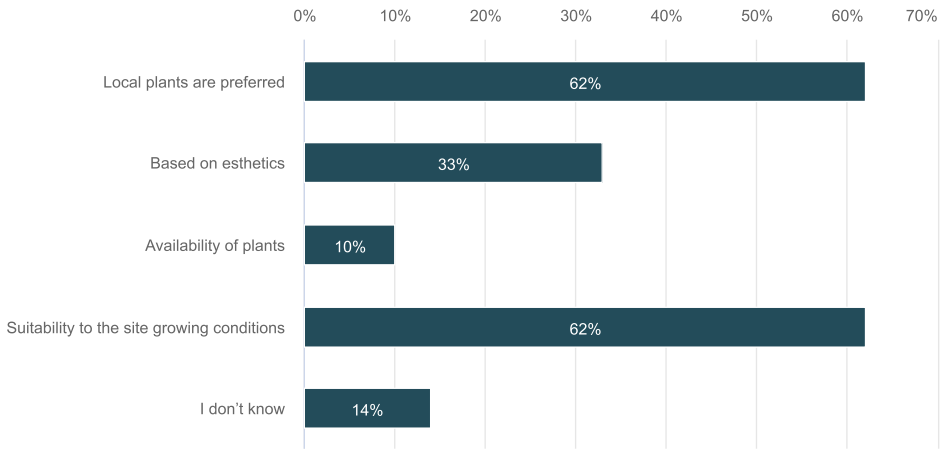


**Figure 3.**
How are the plants selected?

## 3.2 Practices in competitive bidding

Competitive bidding and the process of choosing the contractor for SW filtering structures can be difficult. Information about the expertise in building SW management structures would be needed because 46% of the respondents did not know any contractors with strong expertise in the field (Figure 4.). Previous experience from building SW management structures is considered in competitive bidding in 54% of the cases. Municipal officers consider this more often than consultants, as the figures show that 73% of the municipal officers consider it in the bidding and only 37% of consultants agree. Experience is mostly considered as additional score points in the review. In some cases, the buyer has added a claim about the experience of building at least two filtering systems in the last five years or to submit feedback from previous customers.

Sanctions added to contracts, for cases in which the structures are not built according to plans, are used by 56% of the respondents. The sanctions mentioned are most commonly financial, e.g., the final payment is paid only after the acceptance of the work. Maintenance and reconstruction of the structure during the warranty period is another way respondents are dealing with the issue.

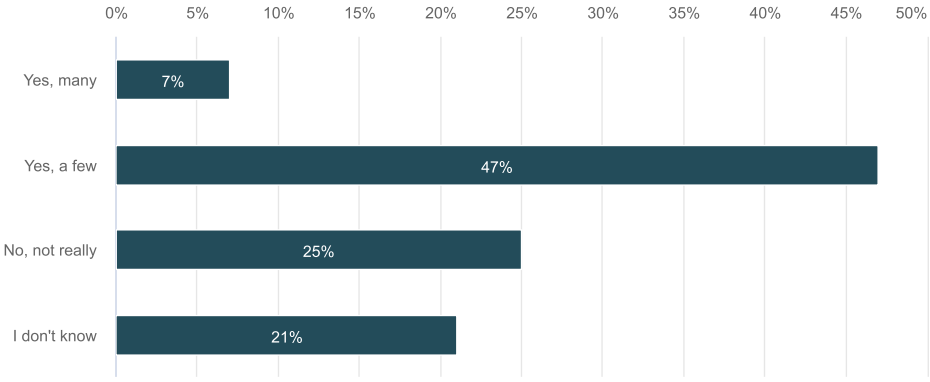


**Figure 4.**
Do you have local contractors with strong expertise in construction of SW filtering structures?

## 3.3 Practices in construction

58% of the respondents have had cases where the constructions have not been made according to the plans. Three main reasons for this are the lack of communication between the planner and constructor of the system, the constructor wanting to save costs and plans that were not realizable (Figure 5.). For municipal officers, the main reason was that the plans were not realizable (71%) and for consultants, communication issues were raised as the biggest reason (67%). Surveillance on the construction phase was seen important and was used by 90% of the respondents.

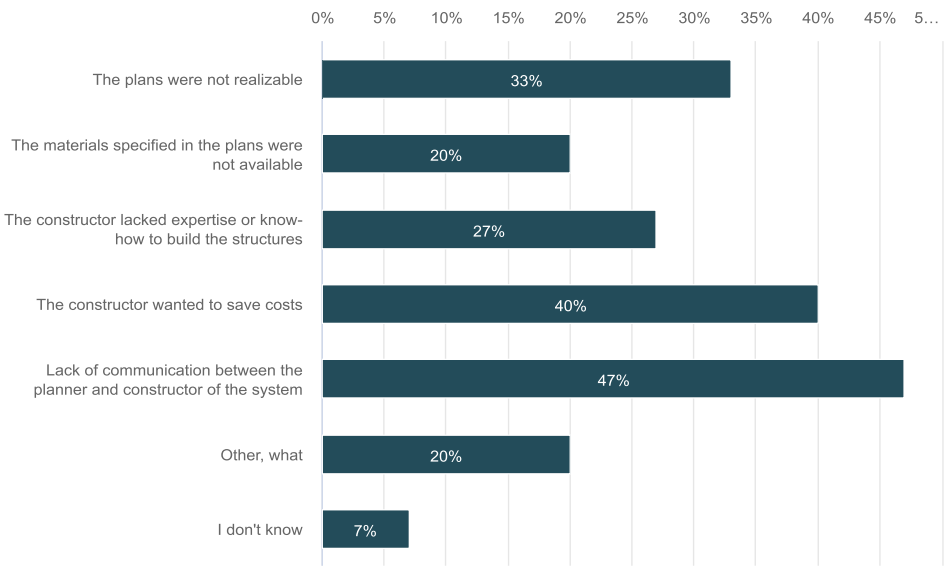


**Figure 5.**
Reasons why the construction has not been made according to plans.

Other difficulties that have occurred in the constructing phase were listed by the respondents in the open text field. A difficulty mentioned in most of the answers was groundwater level being higher than expected. Other issues were difficulties due to inadequate soil investigation, constructor's lack of experience and problems with fitting the structure in the site. These lead into a conclusion about the importance of the background work made before construction.

## 3.4 Practices in monitoring and maintenance

A positive outcome was that constructed SW filtering structures meet the objectives set in the plans and the dimensioning has been successful for 80% of respondents. Plants are growing as planned in 64% of the cases and most respondents think that structures provide significant esthetical values. Some problems with the plants do occur, and they mostly concern wrong kinds of plant choices, e.g., wetland plants are chosen to dry filtration beds.

41% of the respondents carry out monitoring of the filter structures after the construction is finished. Monitoring is executed mainly with water quality sampling with fixed interval e.g., event based, once a week, monthly. Visual assessments, cleaning procedures and reconstructions are also executed. A question about if maintenance activities are carried out for the structures divided the respondents in half. The maintenance activities mentioned were common seasonal maintenance for vegetation such as mowing, removing dead plants and other organic material and watering if needed. Removal of sediment from the sediment trap and rebuilding of filtration layers are done if needed. Problems in the maintenance activities are associated with lack of experience of the maintenance personnel and lack of experience regarding the effective lifetime of the filter media.

On the positive side, 70% of the respondents have not witnessed repeatedly caused problems in their SW filtering structures (Figure 6.). The most common problems were concerning guiding the runoff into the system due to inadequate elevation of the inlet and clogging of the filter media due to pre-treatment failures or wrong material choices.

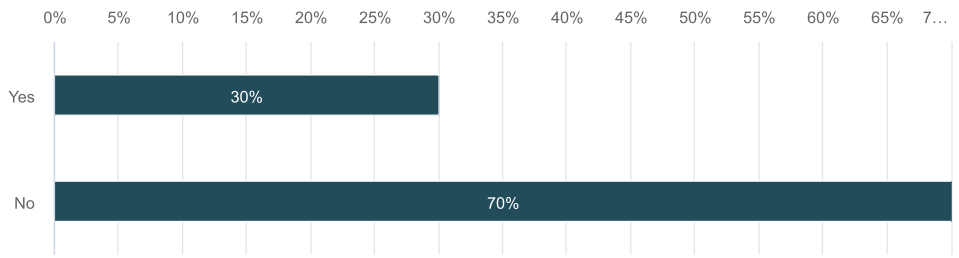


**Figure 6.**
Have you witnessed that some things repeatedly cause problems in stormwater filtering systems?

4

# The check list for quality management

Five different phases that are crucial in the quality management of stormwater structures have been recognized. Each of the phases have their own common pitfalls that can lead to quality problems and best practices which can be applied for quality management. These pitfalls and best practices were shortlisted to provide an overview, or a check list of best practices and things to consider in each phase of realization of a stormwater management structure. The check list will secure fluent planning and bidding processes and help to achieve quality structures that stand the test of time. The check list sheets are mainly directed at municipal officers responsible for the realization of stormwater structures, but they may also be useful for other officials and private companies dealing with stormwater management issues.

The first drafts for the check lists were compiled by the team of Turku UAS, based on the findings from the literature review and questionnaire. The drafts were further developed in the partner workshops held in Riga, Turku, and Viimsi. In all workshops combined, almost 60 experts shared their opinions on the draft check lists and they were modified accordingly. To produce guidelines suitable for each participant country, the special characteristics in e.g., legislation and local conditions have been considered in the sheets.

## 4.1 How to ensure quality in the planning phase

### Common Pitfalls

- National guidelines and/or regulations for stormwater quality management are lacking, making it difficult to set purification targets and efficiency estimates.
- Incomplete or missing information on soil type, drainage area or other crucial parameters may result in unwanted surprises in the operation phase of the structure. For example, the flow is much larger or smaller than expected or the filters get blocked by fine soil particles.
- If the planner has not collected sufficient information on the site and has not visited the site personally, they may have missed some important site features that make the plan unrealizable.
- Stormwater plans have been made in isolation from other infrastructure plans – the result may be a drainage pipe leading stormwater into a sewer rather than into the natural stormwater management structure, or a cabling constructed across previously finalized stormwater solution, destroying the plantations and filtering structures.
- The growing conditions have not been considered in vegetation planning, resulting in weak growth of the plants or the invasion of the structure by other plants.

### Best Practices

- The flow can be determined through the rational method or modeling, however both methods use rough assumptions and include many uncertainties. It is always a good idea to test the calculated flow by measuring or observing the flow on-site during a rain event.
- Planning should also consider the catchment area outside the local plan area. Water flows do not respect plan area boundaries.
- The climate change will change the precipitation patterns – it is wise to take this into account either by dimensioning the structures according to future climate predictions or by planning the structures so that their capacity can easily be increased if needed.
- Soil and topography mapping should include at least drainage divisions, areas prone to erosion, possibilities of filtration, ground water level and possible hazardous substances in the soil.

- v It is important to consider the specific climatic conditions that might affect the functionality of stormwater treatment solutions, such as freezing temperatures.
- v For ensuring cost-efficiency, it is important to choose the return period of the dimension rain by the sensitivity (risk level) of the site.
- v Nature-based solutions are a part of sustainable landscape design. Visually attractive stormwater management structures will contribute to increased acceptance and uptake of natural stormwater management methods by public.
- v Use local plant species and utilize existing vegetation in the area as much as possible.
- v In SW filtering structures, plants should be resistant to both drought and flooding. Choose salt tolerant plants to high traffic areas. Also consider shading and other factors affecting the plants' habitat.
- v Consider ordering plants as early as possible, seedlings and plants of local species often need to be ordered even a year before planting.
- v A good plan also includes a monitoring and maintenance plan!
- v Require detailed plans from the planner, so that they don't leave space for false interpretations by the constructor.

## 4.2 How to ensure quality in the bidding phase

**Common pitfalls**

- Selection of a contractor that does not have experience and know-how to build nature-based stormwater management structures.
- Because of the lack of experience in realization of nature-based stormwater management structures in municipalities, there can be difficulties in clearly communicating the needs and aims of the structures.
- In many cases, the person drafting the bidding documents has no expertise in the field of construction or stormwater management.

**Best practices**

- v Make sure everything you require from the contractors is written in the bidding documents. Using standard texts will make things easier.
- v Requirements for stormwater management during the time of construction should be already included within the call for bids.
- v Valorize experience, e.g., consider contractors' previous experience from building stormwater structures as a qualification criterion or ask contractors to submit feedback from their previous customers as attachment to the offer.

- Set clear sanctions for non-compliance of contracts or plans.
- Define sanctions if problems occur during or after the construction, due to incorrect building practice or materials.
- If the finished structures do not meet the original plans, contractors must fix the structure so that it will be according to the plan.
- When dealing with new innovations or designs, organizing a tender competition also for the supervision of the contract can help to achieve the best possible outcome.

## 4.3 How to ensure quality in the construction phase

### Common pitfalls

- Usually, many different companies work in the same construction site. Problems may occur if all relevant information is not passed to everyone.
- Even the best plans can have bad outcomes, if not understood and followed by the contractors.
- Best timing for building the stormwater filtering structures is not easy to determine and plans might collide with other working phases.
- Construction site runoff often contains high amounts of silt and eventually also hazardous substances and plastic trash. If not properly managed, these may block or otherwise damage the stormwater management structures.

### Best practices

- Organize a meeting with the planner, constructor, and any other concerned actors in the beginning of the construction project to make sure that all necessary information from the planner is passed on to the constructor and to resolve any questions or concerns raised by the constructor.
- Check with the main constructor that all important information is passed also to all subcontractors.
- Build the stormwater filtering structures within dry periods, if possible, to reduce erosion and avoid releases of high amounts of silt. During dry spells it is also easier to install.
- Have regular checkups with the contractor to gain knowledge on the progress of the contract. Visit the construction site regularly to gain better understanding of the things happening at the site.

- v Use existing vegetated areas and depressions as management structures for construction stormwater, alongside with silt fences, erosion blankets etc.
- v Draft a plan how to prevent construction stormwater from causing harmful effects on the receiving waterbodies and environment. If permanent stormwater structures are used for runoff management during the construction period, make sure they are renovated and finalized in the end to ensure functioning!

## 4.4 How to ensure quality in the monitoring and maintenance phase

### Common pitfalls

- If monitoring of the stormwater management structure has not been planned beforehand, it may be impossible to take samples or carry out troubleshooting when needed.
- If servicing procedures, such as silt removal and maintenance of vegetation are neglected, the structure rapidly loses its functionality as well as the acceptance by the local inhabitants.
- Maintenance procedures required by the stormwater management structures might not be clear for the maintenance officers.

### Best practices

- v Water quality sampling and visual assessments should be carried out after the construction has ended to ensure the structure functioning.
- v The roles and responsibilities of the monitoring and maintenance activities need to be determined.
- v Maintenance sheets for every structure provide information about the actual site and its characteristics, to meet the special maintenance needs of different structures. In some cities, all nature-based stormwater management solutions are entered into a maintenance database for sustaining systematic maintenance intervals and for storing information on their state.
- v If some plants wither or otherwise don't succeed, they need to be replaced.

# 5 Conclusions

In this report, the status of SW filtering structures management in the countries participating in the CleanStormWater project was introduced based on a literature review and a questionnaire targeted at municipal officers and consultants. This information was then compiled as check lists concerning the common pitfalls and best practices in the different phases of a SW filtering structure lifecycle.

In the literature review, there were differences between the countries managing SW related issues. SW handbooks were in use only in Finland and Sweden. In Estonia and Latvia e.g., wastewater regulations are used to manage issues related to stormwater. Also dimensioning of the SW structures can be made with standards which are not necessarily made for the purpose. The missing regulations and dimensioning standards along with incomplete background information e.g., about soil characteristics, drainage area and climatic conditions can lead into unwanted surprises in the operation of the SW structures.

Because of the lack of expertise regarding SW filtering structures in municipalities, competitive bidding and constructing of the structures can be difficult. According to the literature review, guidance on competitive bidding in case of SW management structures does not exist in any of the participating countries. Competitive bidding in the construction industry is often dictated with the lowest total price of the contract. When constructing SW filtering structures, other conditions for choosing the constructor should be utilized, because of the special competences needed to get functional structures. Respondents in the questionnaire proposed that implementation of the bidding process by considering experience as additional score points in the review could be beneficial.

It could be achieved i.e., by having claims about previously built filtering systems or a request for feedback from previous customers. Respondents point out that experience of the constructor is mostly considered as additional score points in the review. In some cases, the buyer has added a claim about experience of building at least two filtering systems in the last five years or to submit feedback from previous customers. However, in many cases the personnel drafting the bidding documents might not have any expertise from the field of stormwater management, making it difficult to emphasize the right features. The solution to this issue could be standard texts written by a group of experts, compiling all the needed requirements into phrases that could be used in the bidding documents.

Communication between the stakeholders e.g., municipal officers, planners, constructor, and subcontractors, is certainly an issue to tackle. Based on the questionnaire, consultants wish for better communication to construct SW filtering structures successfully and municipal workers state that the reason why construction has not been made according to plans is because the plans have not been realizable. This could be an issue where municipal workers are not able to express their hopes and needs to the planners leading to plans that are not fit for their place. Set meetings in the different phases of the lifecycle would help to pass information between the different actors and to resolve all questions or concerns early on. Regular checkups and site visits will also help to gain better understanding of the things happening during the construction phase.

Based on the literature review and questionnaire, the multiple benefits gained from SW management structures might not be seen amongst the decision-making personnel in municipalities; thus, the structures are often executed with lowest possible costs. Esthetic values and the importance of plants in SW management structures have been recognized in Finland and Sweden. In Estonia and Latvia, the interest towards more diverse SW management structures has grown within past years. It should be noted that visually attractive stormwater management structures will contribute to increased acceptance and uptake of natural stormwater management methods also by the public and are a part of sustainable landscape design.

All CleanStormWater partner countries are involved in various projects regarding SW quality management, to gain more knowledge and understanding about the issue. The need for monitoring and research data about the long-term effectiveness of SW filtering structures was mentioned both in the questionnaire answers as well as in the workshops. Different filtering structures are built not only because of SW quality measures, but also to bring added values for biodiversity, recreation, and climate change adaption.

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# Appendix 1 Questionnaire

**STORMWATER FILTERING STRUCTURES**

Central Baltic ***Clean Stormwater*** project aims to develop and test new stormwater treatment solutions, that will clean stormwater effectively, ensure management quality and monitor water quality. This survey will provide knowledge for the assessment of existing management of stormwater systems and solutions. The results will be combined in a report, which will be published within the project.

This questionnaire is concerning planning, building and operation of stormwater filtering systems. Stormwater filtering systems are defined as structures that capture and temporarily store stormwater and pass it through a filter bed consisting of different filtration media. Filtered runoff can be collected and returned to the stormwater sewers, ditches or natural streams, or it can be allowed to infiltrate into the soil. Stormwater filtering systems are for example, bioretention basins and cells, vegetated swales and raingardens.

The questions are divided into five different categories:

- Planning
- Competitive bidding and contracting
- Construction
- Operation and maintenance
- Best practices

This questionnaire mostly consists of multiple-choice questions and answering takes approximately 10 minutes. **Thank you for your time and effort in advance!**

**Wich country are you working in?**

- ◯ Finland
- ◯ Estonia
- ◯ Latvia
- ◯ Sweden
- ◯ Other, _____

**What is your working role?**

- ◯ Working as consultant
- ◯ Working as municipal officer
- ◯ Other, _____

**How many residents live in the municipality/city you are working in?**

_____

**Have you been working with planning, construction or maintenance of stormwater filtering solutions?**

- ◯ Yes
- ◯ No

**With how many structures (approximately)?**

_____

## Planning

**What kind of research/investigations are made for the area, where stormwater (SW) filtering structures are going to be built?**

- [ ] Soil quality research
- [ ] Stormwater quality analysis
- [ ] Mapping of the existing, and future land use of the catchment area
- [ ] Topography mapping of the catchment area
- [ ] Other,

**Is there a need for better background data to improve planning of SW filtering structures?**

- ◯ Yes
- ◯ No

**What is missing, what could be better?**

**What is used as basis for hydraulic dimensioning?**

- [ ] Drainage area size
- [ ] Drainage area runoff coeffient
- [ ] Hydraulic modelling
- [ ] Historical rain data
- [ ] Predicted rainfall (Climate change is considered)

**Which rainfall frequency is usually used for dimensioning stormwater filtering systems?**

- ◯ 2 year

- ◯ 10 year
- ◯ 50 year
- ◯ 100 year
- ◯ Other, _____

**Are the plans for the SW filtering structures considering the special characteristics of the site and/or the area?**

- ◯ Yes
- ◯ No

**What is not being considered?**

**Are the plans for the SW filtering structures detailed enough?**

- ◯ Yes
- ◯ No

**Is it causing troubles?**

**Are you using plants on the filtering systems?**

- ◯ Yes
- ◯ No

**How the plants are selected?**

- ☐ Local plants are preferred
- ☐ Based on esthetics
- ☐ Availability of plants
- ☐ Suitability to the site growing conditions
- ☐ I don't know

## Competitive bidding and contracting

**Do you have local contractors with strong expertise in construction of SW filtering structures?**

- ◯ Yes, many
- ◯ Yes, a few
- ◯ No, not really
- ◯ I don't know

**Is the previous experience, that contractors might have from building stormwater management structures, considered in the competitive bidding?**

- ◯ Yes
- ◯ No

**How it is considered?**

**Are any sanctions added to contracts, for the case that the structures are not built according to the plans?**

- ◯ Yes
- ◯ No

**What kind?**

## Construction site and the area

**Have you had cases, where the construction has not been made according to the plans?**

- ◯ Yes
- ◯ No

**The reason for this was**

- ☐ The plans were not realizable
- ☐ The materials specified in the plans were not available
- ☐ The constructor lacked expertise or know-how to build the structures
- ☐ The constructor wanted to save costs
- ☐ Lack of communication between the planner and constructor of the system

- [ ] Other, what
- [ ] I don't know

**What kind of problems have you encountered when constructing stormwater filtering structures?**

**Is there any surveillance by the buyer e.g. municipal officer, during the construction phase?**

- ◯ Yes
- ◯ No

## Operation and maintenance

**Has the dimensioning of the structures met its goals?**

- ◯ Yes
- ◯ No

**What kind of problems have occurred?**

**Do the finished structures meet the objectives set in the plans?**

- ◯ Yes
- ◯ No

**Why do they not meet the objectives?**

**In filtering systems with plants, have the plants grown as planned?**

- ◯ Yes
- ◯ No

**Do you consider the structures to provide significant esthetical values?**

**Why not?**

**Do you carry out any monitoring of the stormwater filters?**

- ◯ Yes
- ◯ No

**What kind of monitoring, how it is excecuted?**

**Do you carry out any maintenance of the stormwater filters?**

- ◯ Yes
- ◯ No

**What kind of maintenance?**

**Are there problems in the maintenance of the stormwater structures?**

- ◯ Yes
- ◯ No

**What kind of problems?**

**Have you witnessed that some things repeatedly cause problems in stormwater filtering systems?**

- ◯ Yes
- ◯ No

**What are those things?**

## Best practises

**Can you tell us about your most successful stormwater cases? Some good plans that were executed on point, or maybe minor details that have had great added values? Share it with us!**