

Manual of Solutions

Implementation and lessons learned
of 7 nature-based stormwater
solutions in Central Baltic countries

Case studies

The MUSTBE project brings together five municipalities across the Central Baltic region to tackle urban stormwater challenges through nature-based and smart solutions. The case studies showcase experiences from two sites in Estonia (Viimsi and Tallinn), two sites in Pori, Finland, two sites in Söderhamn, Sweden, and one site in Riga, Latvia. Each pilot site represents a unique context – different landscapes, governance structures, technical capacities, and community needs. Yet, all share a common goal: to reduce flooding, improve water quality, and create more resilient urban environments.

This section presents a collection of real-life stories from the five participating municipalities. Rather than focusing solely on technical specifications, these case studies emphasise the practical aspects of implementation – the decision-making processes, collaborations, adaptations, and lessons learned. Each story is structured to reflect the full journey – from initial goals and challenges, through planning, design, and procurement, to implementation and reflection.

We hope these stories will inspire, inform, and support the wider adoption of nature-based stormwater solutions across the region and beyond.

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Pori (Finland): Central Square

Central Square is one of two pilot sites simultaneously performed in Pori. This pilot aimed to create a replicable stormwater management solution in a densely built urban area's parking lot by balancing infrastructure, greenery, and climate conditions to reduce flooding, improve tree health, and enhance overall environmental performance. The pilot area is 0.29 ha with a catchment area of 0.11 ha.

The implemented solution includes renewing green lanes and vegetation, adding permeable pavement and sloping of the ground to improve water infiltration and retention.

Background

The Central Square parking lot is located in dense urban area, which creates many pressures on land use. There are a number of competing needs for urban space, such as parking, smooth access for different modes of transport, green spaces and stormwater management. Due to the dense surrounding structure, the capacity of the stormwater network can be exceeded during heavy rainfall, preventing water from draining away from the streets efficiently. At the same time, rainwater leaches harmful substances such as heavy metals and polycyclic aromatic hydrocarbons (PAH) from asphalt surfaces and vehicle tyres.

The vegetation in the Central Square parking lot was previously in poor condition. The existing trees were not growing well – the roots did not get enough water and oxygen due to the dense pavement and compacted soil, and the trees were situated higher than the surrounding ground, resulting in stormwater being unoptimally utilised by the vegetation. In addition, mechanical damage to the roots and trunks of the trees had been caused by maintenance and traffic.



Initial situation.



Central Square before construction. Previously, the trees were situated higher than the surrounding ground.

In winter, stormwater management problems were caused by a district heating line running under the site, which melted snow and ice in the parking lot. This made it difficult to use the parking lot and posed maintenance challenges as the meltwater refroze unevenly.

Overall, the area highlighted the need to better balance technical infrastructure, urban greenery and stormwater management to improve the functionality and amenity of the area.

Planning

The design process started in November 2023 and was finalised in April 2024. MUSTBE partner universities contributed to the choice of pilot site, the catchment area and the water quality parameters. The universities also made the stormwater runoff modelling to carry out the multidimensional impact assessment for the Central Square pilot site.

There were some limitations in the planning stage. The design had to take into consideration multiple different objectives, such as the city’s strategic goals, surrounding infrastructure and public transportation, as well as involve different organisations of the city, such as the environmental planning, traffic and gardening experts. It was also crucial that the number of parking spaced would not be reduced, which affected the design. The location of district heating pipe also added limitations. As these were taken into account already at the planning stage, there were no problems later in the procurement and implementation process in reconciling them.

3D modelling of the solution was considered but eventually rejected due to increased costs. In retrospect, 3D modelling would have been useful as it would have provided more understanding of the different aspects of the solution and how the pilot solution was going to work before any construction work began. This would have been especially helpful in visualising the sloping of the ground and redirecting of the stormwater.



Central Square parking lot before. The pilot area, around 0.29 ha in size, is marked with a red line.

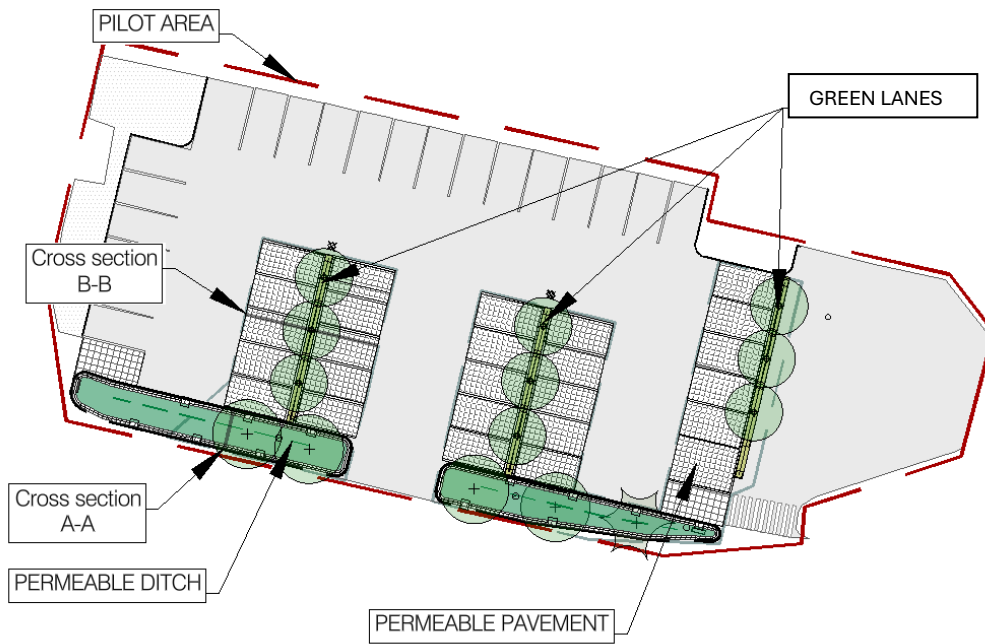
Design

The final design comprised renewing the green lanes in the parking lot and replacing the old trees with new ones, with the aim of more effectively absorbing stormwater and ensuring good growth conditions for the planted vegetation. To ensure sufficient water and oxygen supply to the tree roots, the ground was sloped to direct stormwater to the green lanes, and structural soil was built under the green lanes. Structural soil consists of rock material and finer soil and acts as a supporting structure in paved areas while also allowing sufficient growth space for the tree roots. The plants are protected by a fence, which was designed in-house.

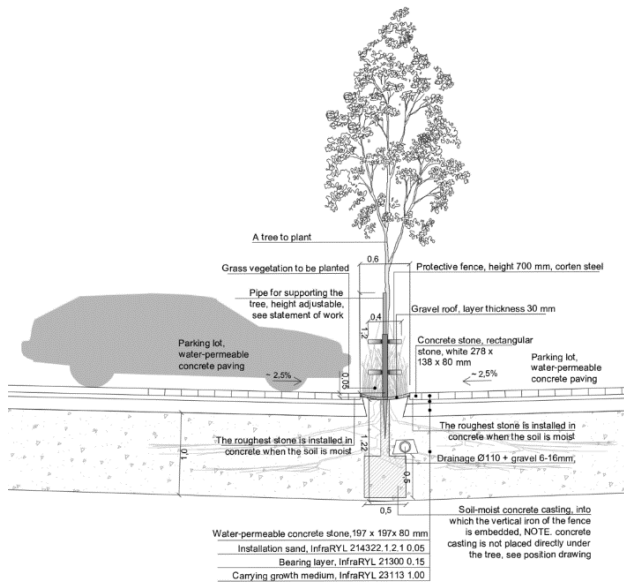
In addition, instead of only asphalt, the parking lot has permeable block paving, which further enhances the absorption of stormwater into the ground. The excess stormwater that passes through this biofiltration structure is further directed through underground drains to the stormwater pipe network.

The goal was to make the solution as low maintenance as possible. The design included round-shaped gravel to be added as mulch to the green lines. A round-shaped gravel prevents the weeds from rooting more effectively than sharp gravel. Initially, the intention was to utilize a very small sized gravel, but in the end, a larger size was used based on positive experiences on its effect on the ease of maintenance. In addition, the plan sought to prevent the growth of weed by planting the plants as densely as possible and adding mulch on top of the soil.

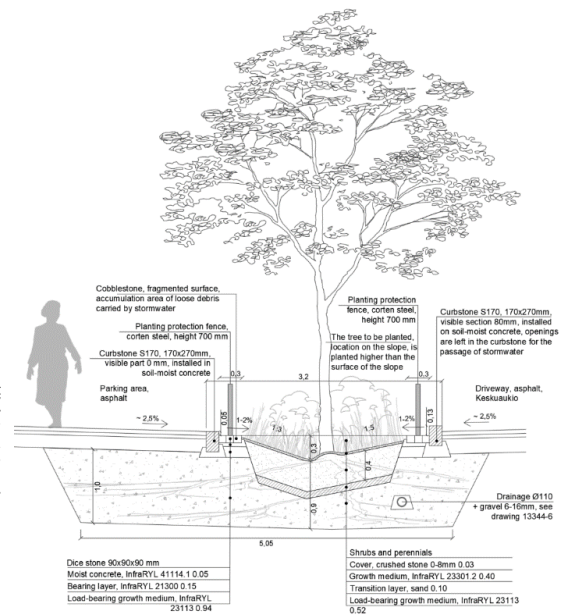
The effectiveness of the Central Square pilot solution is monitored using continuous soil moisture sensors, electrical conductivity, flow and solids meters, and traditional stormwater samples.



Designed solution layout view.



Cross section A-A:
“Stormwater trees” and permeable pavement.



Cross section B-B:
Permeable ditch with trees.

Procurement and tendering

The contractor was required to have civil engineering, infrastructure and hydraulic engineering skills and references, experience and expertise in landscaping and good financial reliability. The tenderer was required to respect the European Union regulations and other general terms and conditions of the contract.

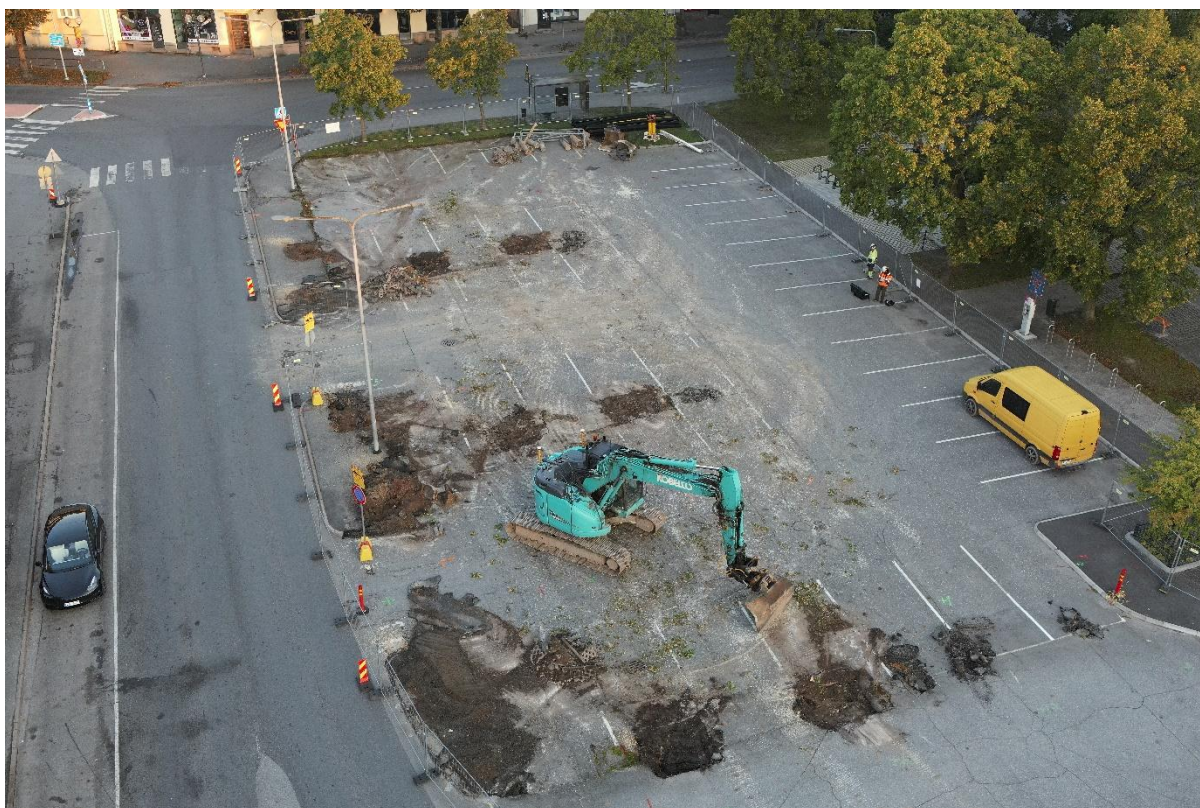
One of the challenges in the procurement and tendering process was urgency. From a municipal point of view, the timeline for the pilot site implementation in the project was much quicker than the municipal process, which brought challenges; the cheapest tender was pricier than what was expected, and the budget had to be exceeded due to the time constraints of the project. In addition, the late tendering process made it challenging to purchase plants.

Another challenge arose when trying to find a landscaping contractor as there were only a few companies operating in this field locally. The municipality of Pori ended up procuring both landscaping and civil engineering services from the same contractor. By separating these contractors, it might have been possible to achieve better expertise in landscaping; however, the communication between two separate contractors could have caused additional challenges.

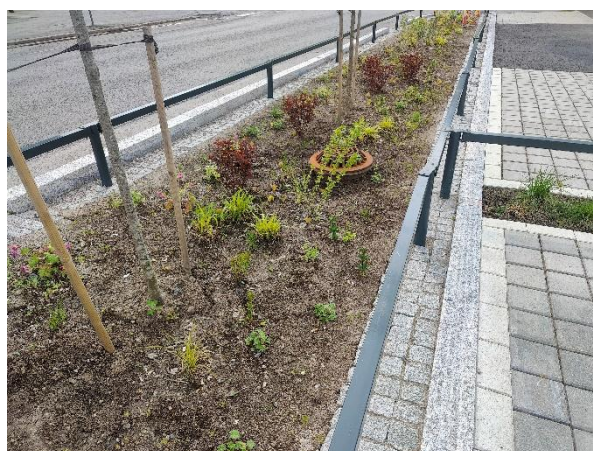
The plans for the fence to protect the planting were not included in the tender and were instead asked for as an additional question at the tender stage.

Implementation

The implementation and construction of the Central Square pilot site started in September and was finished in December 2024. The schedule was pushed far into the autumn and winter, which was not the most ideal situation, at least for the planting of trees and perennials. The foundations were built on fine subsoil sand, which will most likely affect the final results positively in terms of water absorption and outgoing water quantity. Coordination with other infrastructure works was successful – the contractor was mainly responsible for scheduling and coordinating the different infrastructure works.



Central Square during construction in September 2024.



Completed Central Square during the summer of 2025.

One of the key lessons was that the construction work should have been monitored on a daily basis to ensure that it was done carefully and fully according to the instructions. **The implementation of the work specifications should be closely monitored, as the knowledge in the NBS field is not as strong as in conventional civil engineering projects. It is also worth explaining to the contractors why the structures are being built as drawn in the plans.** The construction process moved fast, which made it difficult to monitor the pilot site

construction. For instance, the fence to protect the plantings was built without the concrete foundations and the fences became lower than was planned.

Some modifications and additional work had to be done to the plans, such as adding lighting for the safety of pedestrians in the parking lot. Some small surprises also came up during the construction – in the case of the Central Square pilot site, the monitoring well was initially planned elsewhere, but it was later discovered that this well could not be connected to the stormwater system due to the poor condition of the structure. As such, a new location had to be thought of.

The only delay in the Central Square pilot site project was the installation of the measuring equipment. The equipment could not be installed in winter, and they required their own electrical inspections and measurements. The installation of the metres caused additional costs because not all the details were understood, such as a suitable location and the type of flow meter. There were also problems in connecting the meters, and the monitoring well made the installation difficult as it was very cramped.

Reflections

The construction of the Central Square pilot site was quick, although the simultaneous construction of another pilot site (wetland, see next chapter) slightly slowed down completion. However, the concurrency of the two pilot sites' construction positively increased the re-use and recycling of soil materials; surplus sand from the Central Square pilot site construction was used in the growing medium for the wetland to make it better suited for meadows.

From a design aspect, 3D drawings could have been useful for this pilot site when changing the slopes and the alignment of the surface layers. During the construction, it was noticed that the ground surface had not been sloped in the correct direction, as most of the water was directed to narrow green lines, even though it would have been more optimal for water retention to direct the water to depressions to a greater extent. This could have been prevented by modeling the pilot site's operating mechanism before construction work. The 3D modeling was expensive, but in hindsight, it would have been very useful.

Plans and instructions could have been made even more detailed, with substantial sanctions if things were not done as agreed. For instance, the fences were built without the planned concrete foundations, and the bigger green lanes could have been deeper in depression. It became apparent that small surprises may appear during construction, which need to be solved quickly in order to keep to the schedule. The cost management is not straightforward for projects like the Central Square. The communication between the contractor and the developer plays a key role, and the cooperation should be transparent to prevent any bigger issues.

It also would've been helpful to have more detailed instructions on plant care. The season during the construction work was not optimal for plant growth, which resulted in some perennials dying. The dead perennials were not replaced with new ones the next spring or summer, which caused the green lines to have less vegetation than planned. This also made it difficult to test different plants and investigate which species would be best suited for retaining stormwater in urban areas. A reinspection following spring 2025 raised concerns about how to maintain the growth and well-being of the plantings. The contractor is required to provide two years of plant growth after planting.

Despite the challenges, the Central Square pilot site has so far successfully absorbed the stormwater and prevented any flooding. The pilot site has improved the attractiveness of the area and has served as an inspiration for other stormwater management projects in Pori. During the construction, it became apparent that there is a high potential in using recycled materials in nature-based stormwater solutions. However, using recycled materials in flood preventing solutions and infrastructure is restricted by legislation.

Project documentation

- [Central Square – Design documentation](#)

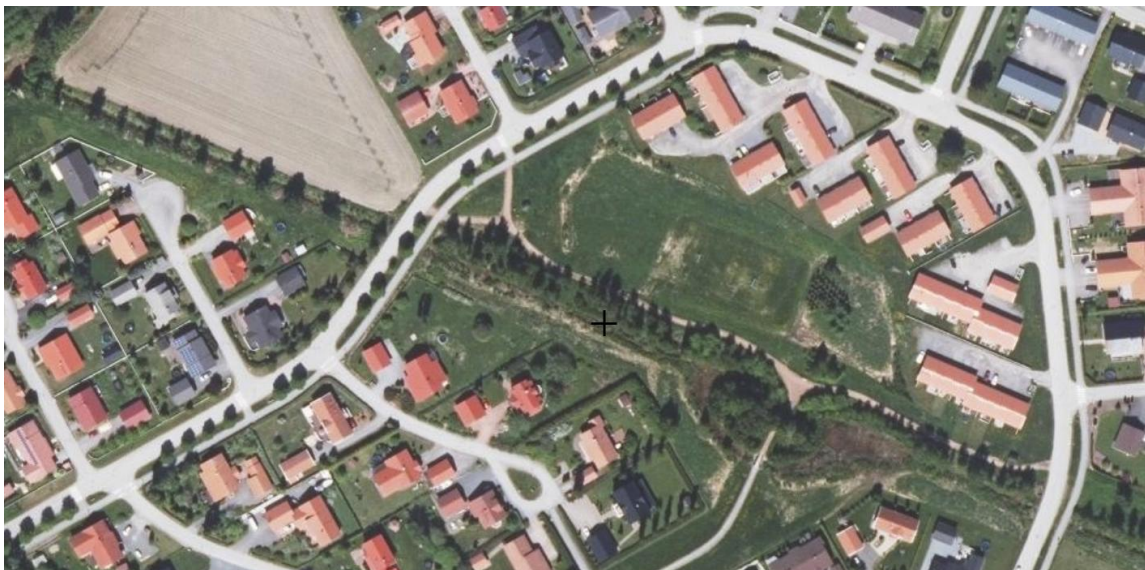
Pori (Finland): Lotskeri Wetland

The “Lotskeri Wetland” is one of two pilot sites simultaneously performed in Pori. The wetland is located in the middle of a residential area in Lotskeri, Pori with a catchment area of 83 ha. This pilot site aims to improve water quality affected by acid sulphate soils, slow runoff into the Baltic Sea, and enhance local amenity by restoring a disused wetland in a residential area.

The designed solution includes retention and settling ponds, a filtration dam system to treat and neutralise the water as well as stone dams to slow the water flow and promote sedimentation. The filtration dams contain biochar and gravel as well as pumice stone and limestone.

Background

Before the restoration of the wetland as part of the project, it had not served its function in many decades. The wetland was built about 30 years ago for stormwater treatment and had not been maintained since, resulting in the area being overrun by vegetation. The main challenge for this pilot site was that most of the water is quite acidic and contains heavy metals due to the area’s location on acid sulphate soils. In addition, the wetland’s water level was very low or non-existent, especially during dry seasons, leading to occasional odour nuisance in the area.

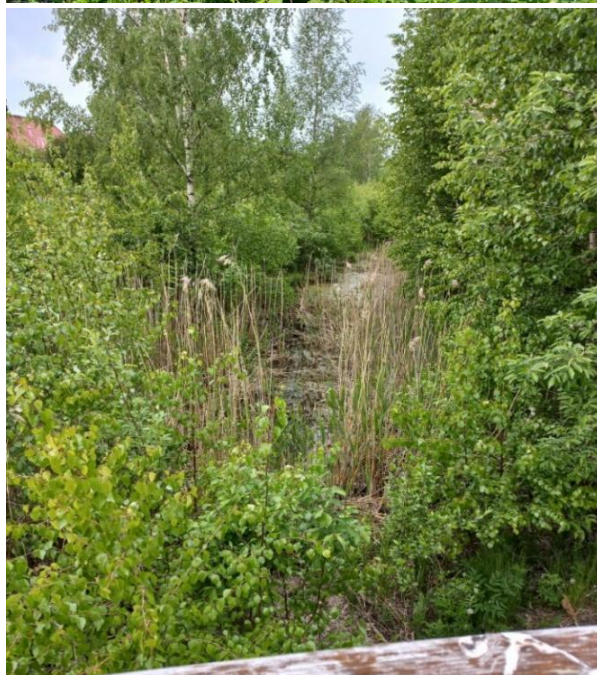


Existing situation in the wetland pilot area. The water treatment area is about 1 hectare in size, and the treatment route is 464 metres long.

In acid sulphate soil areas, any kind of land use, especially excavation and drainage, can lead to the oxidation of sulphur in the soil and the formation of sulphuric acid, which dissolves heavy metals from the ground and reduces water quality. In addition, once the acidic and metallic water mixes with more neutral water downstream of the wetland, the increase of pH causes some of the dissolved metals, such as iron, to precipitate into hydroxides. This leads to

the formation of metal-rich sludge at the bottom of the downstream. Untreated runoff from acid sulphate soils has a detrimental effect on the ecological and chemical state of the receiving water bodies.

The restoration of the disused wetland in the area with a nature-based solution was intended to prevent the metals and acid water from being conveyed to the receiving water bodies by retaining the metals in the wetland and neutralizing the water. The aim was also to enhance the overall amenity of the area and support biodiversity.



The wetland was previously full of overgrown vegetation and hadn't been maintained since its construction.



Wetland after the clearing of overgrown vegetation and before construction in May 2024.

Planning

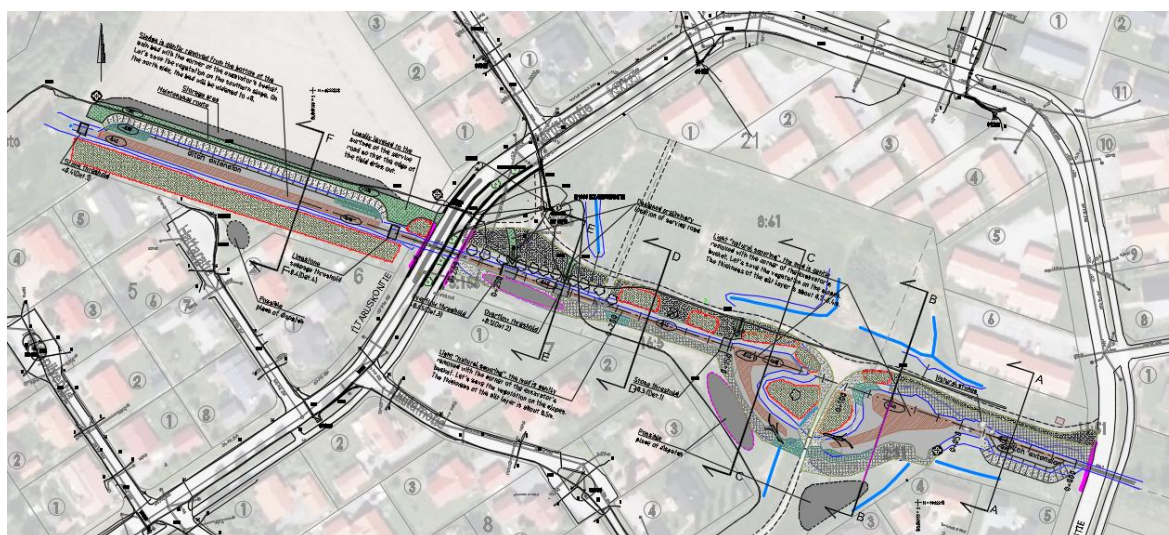
The Lotskeri wetland was a natural choice for the location of the pilot site, as it had been part of another project that focused on acid sulphate soils. The design process started in November 2023 and was finalised in April 2024. The pilot site design was provided by an external design company. There was a relatively clear idea of how to improve the runoff water quality from acid sulphate soils when planning the pilot site design. The construction of the site did not require an extensive network of cooperation within the municipality, and the design was able to be familiarised with a reasonably small number of people. The solutions chosen were relatively typical, which made the planning process relatively easy. Permits had to be granted only for changes in drainage, dredging and cutting down trees.

An easy-to-maintain solution with filtration materials was preferred, although there was a potential for further innovation in terms of ease of maintenance – in the early stages of design, the implementation of a filter basket was considered, but the idea was later rejected due to its higher maintenance requirements. To stay within the budget, some adjustments had to be made

to the original design; the water purifying effect of the plants was considered less effective compared to the primary solution, which led to a reduction of the perennials to prevent the budget from being exceeded.

Some familiar and some new materials were selected as dam filtration materials. Runoff from acid sulphate soils is traditionally neutralised with limestone, but biochar was also selected to experiment with its treatment efficiency in removing nutrients and harmful substances. Tests were carried out to exclude a few materials in advance, such as dolomite and zeolite, which quickly became clogged and were therefore rejected. Dolomite also contains magnesium which caused concern it might dissolve in the water and increase the metal load.

The initial mapping work during the planning phase should have been more precise. The location of a drainage pipe, which discharges stormwater collected from the nearby residential area, was not known until the end of the construction work. This led to the solution's dam system being placed unoptimally. The drainage pipe has had a significant impact on the water quality of the wetland even after the implementation of the solution.



Designed solution.

Design

The wetland pilot site design comprises a filtration dam system and retention and settling ponds. There are also stone dams to slow down the flow of water and promote sedimentation. First, the water flows into retention ponds where suspended solids are removed. The water is then filtered through two filtration dams that contain biochar and gravel, to help remove harmful substances and nutrients. This is followed by the last filtration dam containing pumice stone and limestone, which aims to neutralise the acidic water. Lastly, the water flows through a settling pond where the dissolved metals in the now more neutral water precipitate. From the settling pond, the metal-rich sludge can be more easily removed by the city's maintenance

department, preventing it from ending up in receiving water bodies. For sludge removal purposes, a maintenance road was set up at the settling pond.

The effectiveness of the wetland pilot solution is continuously monitored by measuring the flow of water, the pH of the water before and at the end of the wetland, and the level of perched groundwater. In addition, traditional stormwater sampling was carried out during 2025, and precipitation is monitored with a nearby weather station. Lastly, a sediment sample was taken from the formed sediment to determine the final disposal site.

Procurement and tendering

The procurement took place from April to May 2024 through a public tender in accordance with the regulations. The criteria used were expertise and experience in civil engineering, infrastructure, hydraulic engineering and green space management. This combination of competences resulted in only one tender being received. Although the tender was quite expensive, it was within an acceptable range of the budget. The decision was confirmed in July 2024.

It should be worth noting that procurement and tendering for construction projects takes time, and it is worth documenting as much detail as possible, which is important in the procurement process.

Implementation

The construction of the pilot site started in August and finished in October 2024. The schedule was tight as construction started in late summer and involved planting. Some of the planting could not be done in the cold season, so it was completed the following spring. As the surrounding infrastructure in the area was carefully identified in the beginning planning phase, no significant inconvenience was caused by it.

First, the existing vegetation in the overgrown wetland was cleared with the aim of preserving as much of it as possible. During construction, the presence of invasive species caused some challenges, such as the need to inquire whether there were any special requirements for the disposal and monitoring of invasive species. The removal of the invasive species was carried out as a public volunteering event for nearby residents in June 2025.

The wetland was also dredged from the previously accumulated silt – there was no need to apply for a water permit as the sediment from the acid sulphate soil had already been previously analysed and there was no deeper digging involved. There was a higher-than-expected amount of dredged material, but fortunately, there was additional space on the site where the dredged material could be dumped and a permit for it was granted. Due to these unexpected events, there was a slight increase in costs.

The latter part of the wetland is adjacent to a field, which caused some inconvenience during the construction, but this was dealt with successfully between the farmer and the contractor.



Wetland after construction. Due to the dams, the wetland now has a permanently higher water level.



The wetland pilot solution features two different types of filtration dams. The first photo shows the biochar and gravel dam, and the second photo shows the limestone and pumice stone dam.

Reflections

Overall, the procurement and construction of the pilot site were successful. Acid sulphate soils and the need for liming were known from the start, which made it easier to recognise the necessary measures to take. The concurrency of the two Pori pilot sites' construction positively increased the re-use and recycling of soil materials; surplus sand from the Central Square pilot site construction was used in the growing medium for the wetland to make it better suited for meadows.

Regarding the design, a more detailed design could have been asked for; for example, the guaranteed maintenance of the green plantings could have been documented in more detail. A two-year guarantee for planting and maintenance is a good thing to require.

The dredging of the wetland was more extensive than planned, which led to a higher amount of solids in the water than preferred. The aim was to dredge the watercourse in moderation and avoid draining acid sulphate soils. It was not possible to carry out only partial dredging, which harmed the vegetation of the water body and possibly had a negative impact on water analyses due to the erosion effect.

The location of the drainage pipe from the stormwater drain was unknown during the planning and construction phases. The drainage water is directed to the wetland and carries great amounts of acidic and metallic water, as the whole residential area was built on acidic sulphate soils. The poor quality of the drainage water has had a significant impact on the quality of the water in the wetland even after the implementation of the solution. However, the goals of the project were achieved for the most part for total metals.

The operation of the filter dams has also posed some challenges. The filtration worked fine until the filter particles were clogged by the precipitated metals. This lowered the filtration efficiency. First attempt was made to unclog the filter particles mechanically, but it was unsuccessful. To reduce the risk of flooding due to the clogged filtration dams, the dams were lowered to allow more water to pass through. With more time, it would have been possible to make a more comprehensive background work and take the design even further.

To ensure the suitability and performance of the nature-based solution, it is important to have as much knowledge as possible of the objectives and the impact of the structures when designing the solution. The nature-based solutions are new, which makes it important to find networks, gain knowledge, and listen to other's experiences. In addition, more innovation and research are needed for the treatment of acidic metal-rich waters.

Although there have been some unpredictable challenges, the pilot solution can be considered successful. The wetland has deepened the understanding of acid sulphate soils and given concrete information on how the wetland can be used to mitigate the effects of metals and acidity. Later, the goal is to invest on to another water treatment system for the water from the residential area. There are also plans to increase the sedimentation pond or use suction dredging to remove the accumulated sludge.

Project documentation

- [Wetland – Design documentation](#)

Viimsi (Estonia): Fountain Square Pocket Park

The Viimsi pilot site is located at Randvere Road 21 in Haabneeme Parish, Estonia, covering an area of 0.35 hectares owned by Viimsi Municipality. The stormwater system catchment area is 11.6 ha. The Haabneeme township is set to become one of the key activity hubs along the main street, which makes it essential to offer residents access to abundant greenery, parks, and recreational spaces.

The site is located near an escarpment, which discharges significant volumes of groundwater, leading to frequent flooding during heavy rainfall or snowmelt. The pilot site aims to mitigate flood risk and improve water quality by implementing a smart, nature-based stormwater management system in the area. The designed solution includes a retention pond with a smart regulation valve and a stormwater fountain.

Background

The pilot site is situated near Lubjamäe limestone escarpment, where groundwater and stormwater naturally flow and accumulate in the area. The escarpment discharges groundwater significant amounts throughout the year, which has caused frequent flooding during heavy rainfall and snowmelt. Additionally, runoff from nearby traffic junctions introduces pollutants into the stormwater system, which ultimately degrades the water quality of the Baltic Sea.

The location was chosen due to its strategic position within a catchment area affected by runoff from traffic-heavy streets and its direct connection to the Baltic Sea. The municipality identified the need for a nature-based solution that could both reduce flood risk and improve water quality, while also contributing to the renewal of the central urban space.

Groundwater is the primary source of drinking water in Viimsi. Due to the site's location on a peninsula with blue clay subsoil, groundwater recharge is slow. Water levels in the groundwater table have lowered and seawater poses a risk to the groundwater with the peninsula surrounded by the sea on three sides. Therefore, the pilot solution also aims to demonstrate how stormwater can be used in urban solutions instead of drinking water to save resources.



Layout view of the previous situation on the pilot site.

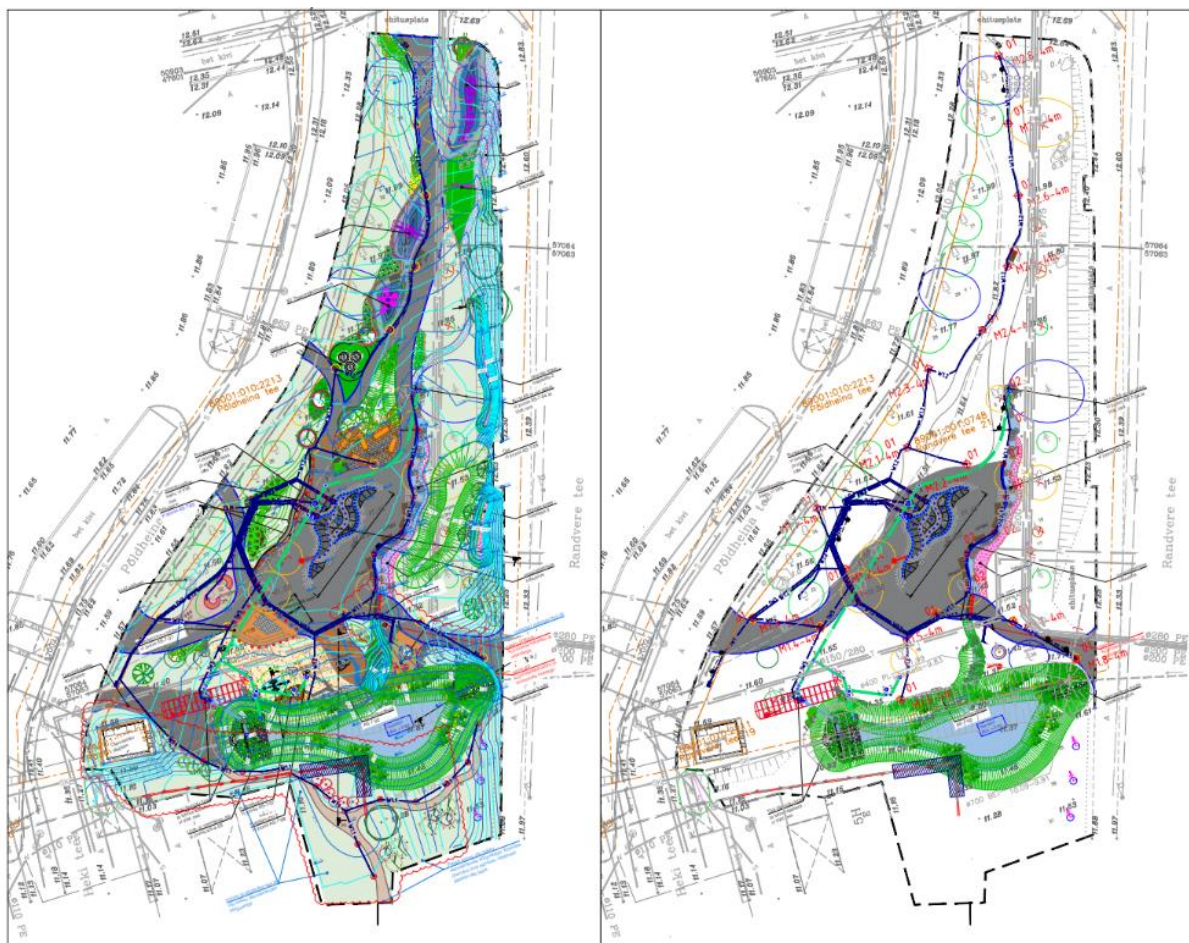
Planning

Before MUSTBE, there was already an initial technical design planned for the area. During the planning phase, the main target was to edit this technical design so that it fitted better to the project's budget and objectives.

The editing of the initial design was done by Tallinn University of Technology (TalTech). Their input included a modified design sketch and active participation in planning and design meetings. TalTech's design emphasized the nature-based approach to stormwater treatment, multifunctionality of the area and cost-efficiency of the solution.

Design

The technical design for the Viimsi pilot solution includes a smart nature-based stormwater system featuring a retention pond and a public fountain square with the aim to slow down the flow of water and improve the water quality entering the stormwater pipe network. The solution includes pumps, filters, UV and disinfection systems, water level and wind sensors, and automated lighting control. The square features 66 LED lights, modern paving, new street lighting, and a water play area, demonstrating how rainwater can be reused sustainably in public spaces.

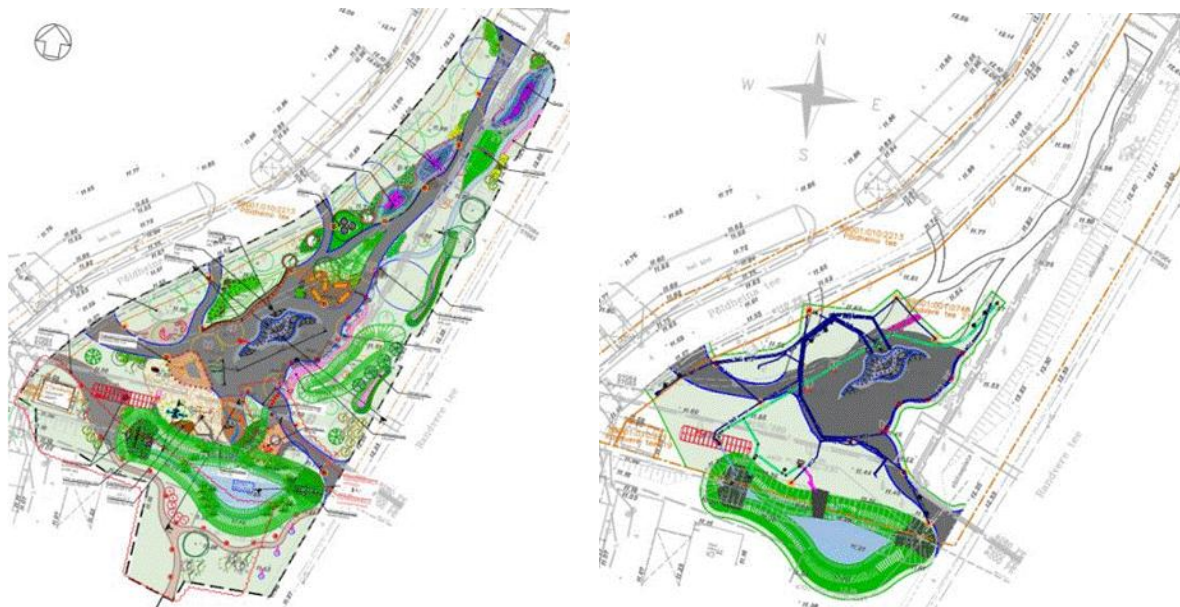


Planned pilot site layout (left) and construction phase I layout (right).

Instead of directing the catchment area's runoff away through the conventional sewer system, flows are delayed and balanced in a 460 m³ retention pond, where natural purification processes, such as sedimentation, take place. The retention pond is equipped with a smart regulation valve. In addition, the pond includes a concrete retaining wall and an automatic damper with a control system. The damper works based on the water level and water quality data.

The water level is continuously maintained at a predetermined height by adjusting the opening of the damper accordingly based on the reading of the water level sensor. For example, if the predetermined level of the water is exceeded, indicating torrential rain, the damper is completely closed and the pond begins to collect rainwater, thus preventing a large amount of water entering the pipes following the pond. When the water level in the pond is stabilized, the damper opens up slowly, letting the water out and lowering the water level back to the predetermined level. In the opposite situation, when there is a shortage of water or the water level is below the critical point, the damper is automatically closed to retain water.

In addition to the water level, the damper is controlled by water quality parameters, such as turbidity and electrical conductivity. To ensure that the water is properly purified before it enters the fountain, the predetermined limit values of water quality can't be exceeded. The information from all the sensors and automation is concentrated on one controller, which is located in a central control cabinet on the pilot area. From the central control cabinet, pre-programmed control commands are transmitted to pumps, lights, dampers, etc.



The water is pumped from the retention pond to the fountain tank and used in the fountain, contributing to sustainable water use and landscape integration. A pressured sewer piping is installed to direct the treated stormwater from the fountain to the existing stormwater pipe network. The fountain square is complemented with lighting and paving.

The site is designed to incorporate a recreation and leisure area that also enhances greenery and raises awareness about sustainable water use. The fountain uses treated stormwater, providing both educational and aesthetic value. During droughts when the fountain is not operational, it also indicates to nearby residents to use drinking water more wisely. Landscaping and

recreational elements are integrated into the design to enhance public use and functionality of the area.

Procurement and tendering

In order to develop the solution, a public procurement was carried out and the developer of the project area was found following standard procedures. The first procurement failed for the design being too expensive, which made it necessary to divide the solution into different phases starting with the first stage of the solution. The design was scaled down with some elements being reduced for the second procurement which proved to be successful.

The constructor responsible for the site was simultaneously involved in several other infrastructure developments across Viimsi, having previously won and executed multiple tenders in the central area. These include the reconstruction of two rainwater ponds in Mõisapark under the BaltCF project, and the installation of a rainwater collection and reuse system on Randvere Road as part of the LIFE program project LATESTadapt. The redevelopment of Haabneeme's main street is progressing in stages, with several adjacent areas – such as Mereranna tee and Tammede Park – already renovated. Altogether, the central area of Viimsi has undergone significant renewal in recent years, with further improvements planned in the coming years.

Implementation

Construction in the project area was completed in November 2025. Some delays occurred from the contractor's side and were mainly due to the complexity of the fountain – there were no challenges regarding the nature-based aspects of the solution.



View from the outflow of the designed sedimentation and detention pond.

As mentioned earlier, due to budget constraints and the complexities of implementing a solution that is novel to the region, the pilot is carried out in stages. In the completed first phase, selected components, such as the stormwater pond and the stormwater-fed fountain, were prioritised to demonstrate key functions like flood reduction, water purification, and reuse. This phased approach allows for gradual integration, testing, and adaptation, with the possibility of expanding the system in future stages depending on available funding and municipal planning.



Designed automatic water flow regulation valve on the pond outflow pipe.



Underground chambers of the designed fountain.



Construction of the above-ground part of the fountain.



Construction of the above-ground part of the fountain. The green tubes are the nozzle tube ends.

Overall, although some things could have been done quicker, the implementation of the solution went quite well and the outcome is positive.

Reflections

The Viimsi pilot solution demonstrates how a complex, multifunctional stormwater solution can be delivered through strong collaboration, adaptive planning, and phased implementation. The design phase proceeded as planned, supported by effective collaboration with TalTech. However, the final construction cost exceeded initial forecasts by approximately 25%, reflecting both market conditions and the complexity of the solution. Due to the exceeded budget, some modifications were needed, such as omitting some of the sensors that were initially planned to be included. In retrospect, it would have been beneficial to limit more of the technical aspects of the first procurement. This would have allowed the construction works to start sooner.



The finished stormwater fountain square.

The main challenges emerged from the grey-infrastructure elements as opposed to the nature-based components of the solution. Particularly the stormwater-fed fountain proved to be the most technically demanding part of the construction. Despite these challenges and some delays, the implementation was completed successfully. Trees and bushes as well as benches will be added to the area in the summer of 2026.

A phased approach has proven effective, enabling the municipality to implement key components first while keeping the option open for future additions such as a playground when funding allows. The greatest success of the pilot is that a fully operational and innovative stormwater solution is now in place, even under tight budget and scheduling conditions. Its long-term performance, especially regarding water quality improvements and the functioning of the automated systems, will become clearer over the coming years.



The completed retention pond.

Project documentation

- [Viimsi – Design documentation](#)
- The first fountain square technical design procurement <https://riigihanked.riik.ee/rhr-web/#/procurement/3612676/general-info>
- The first construction procurement (failed due to exceeded budget) <https://riigihanked.riik.ee/rhr-web/#/procurement/7271184/general-info>
- The final construction procurement <https://riigihanked.riik.ee/rhr-web/#/procurement/7844404/general-info>

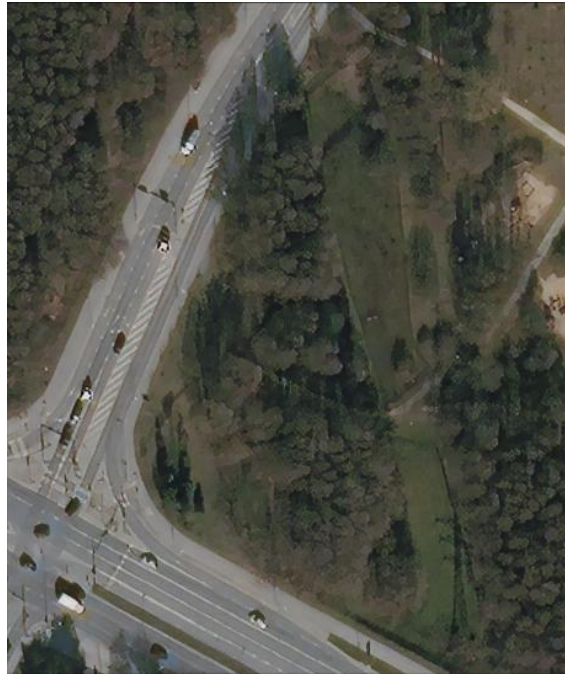
Tallinn (Estonia): Tondimõisa Park

The Tallinn pilot site is located in Tondimõisa Park, adjacent to Tammsaare Road, a densely built and heavily trafficked area that is prone to flooding due to an overloaded stormwater drainage system. The pilot site aims to mitigate flood risks and enhance water quality by constructing a stormwater retention and treatment facility that manages stormwater before it enters the urban drainage network.

Tondimõisa Park, situated at Nõmme tee 107, spans 2.56 hectares, with the planned integrated solution covering 0.58 hectares. As part of the project, a portion of the stormwater from the existing collector on Tammsaare Road is diverted into the park area. Within the park, the stormwater will be buffered and treated before being redirected into the existing stormwater pipeline along Nõmme tee. The maximum flow rate of stormwater directed into the park is 0.4 m³/s. The solution comprises a junction structure, monitoring manholes, a vortex-type separator for oil, debris and sediments, stormwater ponds, a soil filter, a manhole with weirs for water level regulation, recreational areas, and automated control.

Background

The project was initiated to address recurring flooding along Tammsaare Road in Tallinn, primarily caused by an overloaded underground stormwater collector that cannot handle peak flows during intense rainfall events. This issue has led to frequent flooding in certain sections of the street, prompting the need for a targeted intervention. The pilot aligns with the city's broader climate adaptation goals and was developed collaboratively by the local water utility and TalTech, with strong support from the municipality.



Layout view of the existing situation on the pilot site.



Previous situation on the site.

Planning and selection of the pilot area

The Järveotsa stream and specifically an area on the Iisaku stream was initially proposed as the pilot site, but a comprehensive mapping of Tallinn’s stormwater bottlenecks conducted in mid-2023 revealed that the area around the Pärnu Highway viaduct on Tammsaare Road was among the most problematic in terms of drainage. This location was selected due to its high concentration of runoff sources, including dense urban development – rooftops, streets, industrial and commercial zones – with both existing and planned infrastructure contributing to significant stormwater volumes.

Additionally, the area experiences one of the highest traffic loads in Tallinn, which correlates with elevated pollution levels in stormwater, such as heavy metals, nutrients, suspended solids, and oil products. The pilot site at Tondimõisa Park, adjacent to Tammsaare Road, was ultimately chosen for its strategic location, visibility, and potential to raise awareness among real estate developers and urban designers. Its proximity to the city centre (4 km) makes it more accessible and publicly engaging than alternative sites like the Iisaku stream (7 km from the

centre). The chosen site also has the potential for future extension into the neighbouring Pardiitiigi park.

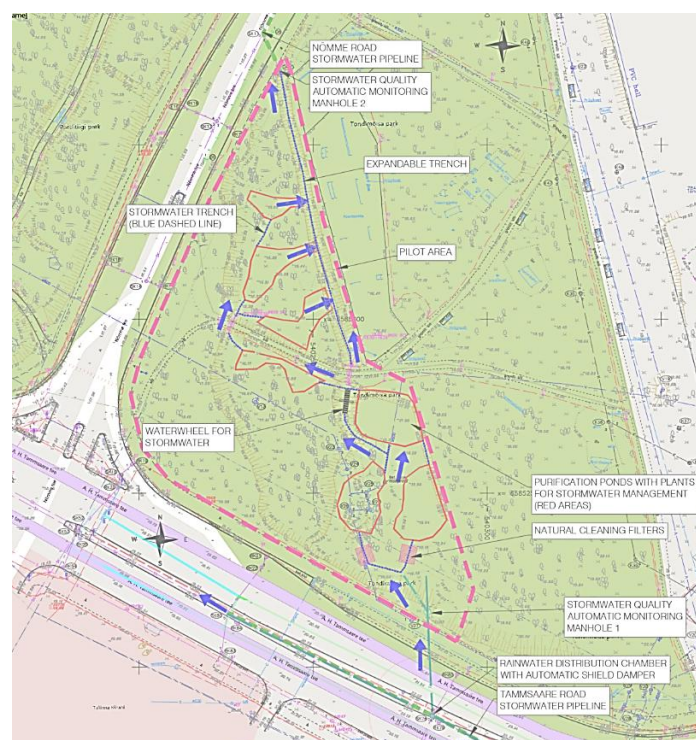


The first pilot area, which was mentioned in the application, is marked in red, and the second area that was proposed and selected during the project is marked in green.

The planned solution aims to reduce suspended solids (SS) and total nitrogen (Tot-N) concentrations at the outflow to below 39 mg/l and 1.2 mg/l, respectively.

Comparison table of the two pilot site areas for the MUSTBE solution.

	Application	Proposal	
Headwaters	Järveotsa Stream	Mustjõe Stream	Mustjõe Stream
Catchment Area of Headwaters	ca 10 km ² (Järveotsa Stream +Iisaku Stream)	ca 11 km ²	ca 11 km ²
Pilot Site	Iisaku Stream	Tondimõisa NBS (Stage 1)	Tondimõisa and Pardiitiigi NBS (Stage 2)
Stormwater Sewerage Catchment Area of Pilot Site Today	35 ha	37 ha	200 ha



Planned pilot site layout.

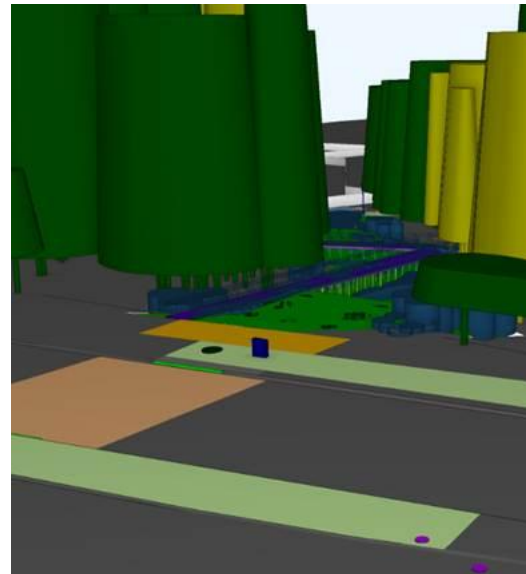
Design

The pilot solution was designed to function both as a stormwater retention basin and a treatment facility, addressing peak flow reduction and water quality improvement. The design was developed through a public procurement process and refined to meet budget constraints.

The initial design proved to be too expensive. For example, it was planned that a footpath on screw piles will be constructed above the wetland area in Tondimõisa Park featuring integrated LED lighting and resembling elevated boardwalks commonly found in bog trails. These features were removed due to the budget cuts but may be added in future stages if the funding can be found. Despite this, the core infrastructure of the final design remains focused on delivering environmental and hydrological benefits.



View of the initial situation from Tammsaare Road.

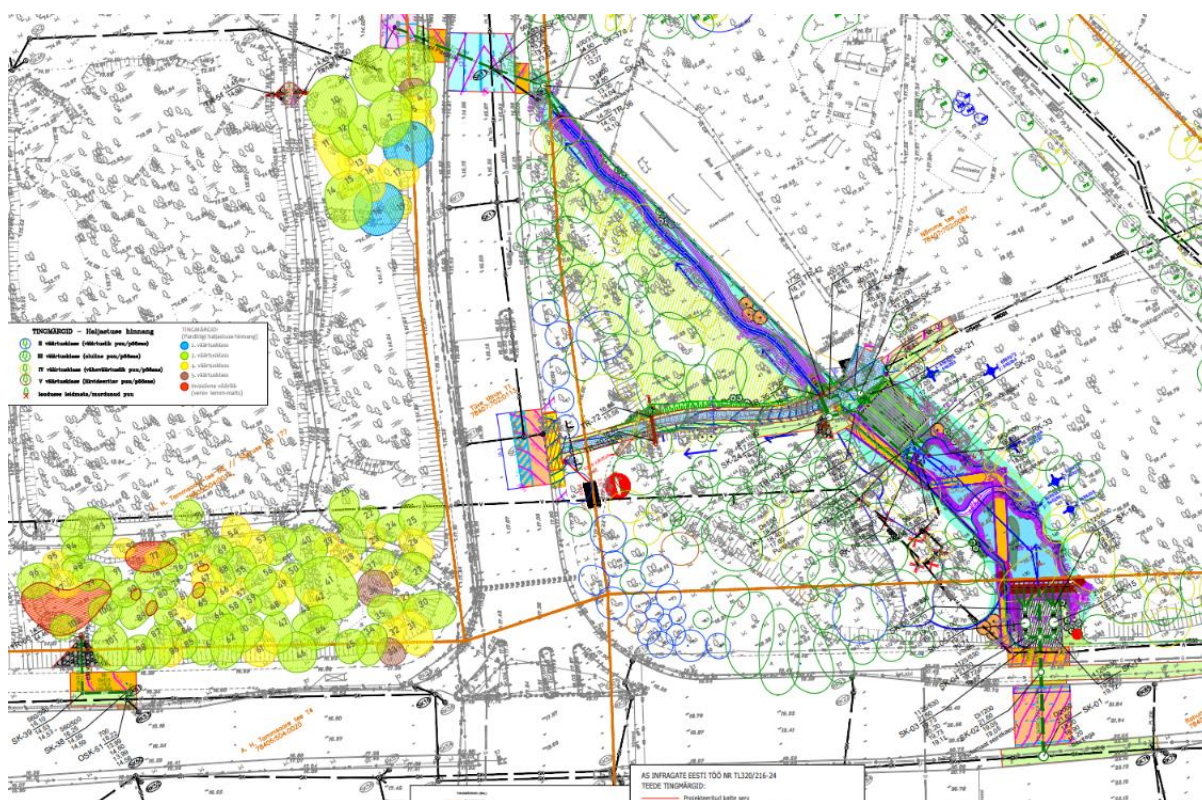


View of the designed BIM solution from Tammsaare Road.

The system begins at the existing stormwater collector on Tammsaare Road, where a distribution junction is installed to divert up to 0.4 m³/s of stormwater into Tondimõisa Park. This node includes an electrically operated knife gate valve, a gate position sensor, and a non-contact water level sensor, allowing for controlled diversion and monitoring.

From the distribution node, stormwater flows into the first automatic monitoring well, which measures key water quality indicators such as suspended solids, total nitrogen, and petroleum products. This well is equipped with sensors for water level, temperature, turbidity, and electrical conductivity. Next, the water enters a vortex-type hydraulic separator, which removes oil, larger sediment particles, and floating debris. Water then flows into the first retention pond (volume: 125 m³), followed by a rapids area and a second pond (volume: 80 m³). The retention time in the ponds is approximately 6 hours, except during peak flow events.

After the second pond, water is partially directed to a pilot soil filter, preceded and followed by sampling wells to assess purification efficiency. The soil filter provides additional treatment, targeting pollutants such as suspended solids, nitrogen, and oil products. To regulate water levels, a regulating well with electrically operated dampers is included. In cases of maximum flow, excess water is diverted to an overflow well, which can direct stormwater to the neighbouring Parditiigi park, a naturally flooded area similar to a wetland.



Designed solution layout.

Before re-entering the urban drainage system via the Nõmme Road stormwater pipeline, water passes through a second automatic monitoring well, equipped with the same suite of sensors as the first. These monitoring points enable assessment of the treatment system’s performance and its impact on stormwater quality.

Additionally, the existing stormwater pipeline on Tammsaare Road is diverted to Parditiigi Park, with provisions to redirect excess flow from the Nõmme Road pipeline if needed.

Procurement and tendering

The project was implemented in two stages, beginning with the design phase, which was procured through the public procurement register. Due to the technical complexity of the facility, the number of bidders was limited, but those who participated demonstrated sufficient competence to carry out the work. The design process proceeded smoothly, with no significant deviations. However, during budgeting, it became clear that the implementation costs would significantly exceed initial estimates. As a result, additional financing options were explored even before launching the construction procurement.

The construction phase was also procured via the public procurement register. As mentioned before, some elements of the original design were excluded from the first procurement round to stay within budget. Despite efforts to control costs, the final procurement turned out to be substantially more expensive than anticipated. Fortunately, additional funding was secured from the city government budget, allowing the project to move forward. At the same time, applying for additional funding also resulted in a time loss of 2 to 3 months in the planned schedule.

Implementation

The construction of the Tallinn solution started in the summer of 2025 with most works, such as the ponds and underground works, completed by the end of that same year. Automatic systems were completed in the spring of 2026 followed by the planting of vegetation.

The biggest challenge during construction was having to make changes to the technical solution due to outside factors. Tallinn water company had plans to renovate a drinking water main which crossed the pipeline system in the solution. The plan was that new pipe would replace the old one in the same place which was taken into consideration in the design phase of the Tallinn solution. However, after the renovation works started, and a few months before the start of the Tallinn pilot solution construction, it was understood that the pipe depth would have to change. The new pipe was in the exact same point as a pipeline in the pilot solution which resulted in having to restart the design work. It took three months to redesign the technical solution due to this issue. The initial contract end date with the constructor was in February 2026 but due to the technical solution changes and the scheduling delays caused by it, the end date was rescheduled in June 2026.

Despite most of the works being complete by the end of 2025, the testing of the solution could only begin the following spring, after all snow had melted. This was due to salting of the streets – stormwater could not be directed to the solution as it would have been damaging to the plants.



First pond connection with the pipes from the Tammsaare Road.



View of the designed ponds (downstream view).



Second pond overflow.



Soil filter after two pond system.



Downstream view of the drain ditch.



Upstream view of the drain ditch.

The solution's maintenance is separated into two: the water company will maintain the pipes, sluice, sensors and supervisory control and data acquisition (SCADA) while the ponds and open solutions will be maintained by the city government. While the water company usually only deals with drinking water and wastewater, the division of maintenance is due in part to city governments not having their own SCADA systems which are essential when setting up smart systems and sensors but expensive to create. Fortunately, the negotiations were successful in setting up the division of maintenance.

The incoming and outgoing water quality is monitored with automatic sensors to demonstrate the solution's effectiveness. The monitored parameters are conductivity, turbidity, pH, temperature and water level. However, monitoring of the solution's effectiveness can be hindered by the pilot being an open area – during heavy rains, rainwater can flow from the surrounding area directly into the solution, which may make the water leaving the system of poorer quality than the water directed to the system.

Reflections

The Tondimõisa solution represents the largest nature-based stormwater management initiative of its kind in both Tallinn and Estonia. If the solution works as planned, it is hoped that Tallinn and other cities will follow example and plan their own similar systems.

The project progressed steadily despite facing challenges in every phase of the project, starting with the change of the pilot area. Main issues were particularly related to budget overruns and coordination with overlapping infrastructure works in the area. The need to secure additional funding caused delays of several months, and the simultaneous relocation of a drinking water main by the local water company required careful coordination between contractors and resulted in additional time lost. In addition, some trees could not be cut down as planned due to objections from the nature department. **The challenges faced in the Tallinn solution illustrate the complexity of multidisciplinary stormwater projects and how much time projects of this scale need.**

Even though the solution is nature-based, the systems are not simple in terms of design, construction and schedule. For example, automation and SCADA systems are not quick to plan and implement. In addition, in Estonia, the city is responsible for stormwater management instead of local water companies – however, cities do not necessarily have similar water expertise that NBS may require. This also highlights the need for maintenance and its responsibilities to be negotiated in advance during the planning and design phase.

Despite the issues, the project's visual and functional outcome is considered highly promising. The rapids feature and pond system are expected to become attractive public elements and effectively address stormwater challenges in a problematic traffic area of Tallinn. Some features, such as a walking bridge, lighting, and fountains, were removed due to budget constraints but are planned so they can be added later if funding becomes available.



The first retention pond.

Looking ahead, the pilot is expected to contribute to improved ecological conditions in the Mustjõgi stream, reduced pollutant loads entering Kopli Bay, and enhanced biodiversity and recreational value in the Tondimõisa and Pardiitiigi catchment area. The monitoring data will provide valuable insights into the performance of nature-based solutions in urban settings and inform future planning and investment decisions. The experience has also increased knowledge and understanding regarding the implementation of NBS and at which point it is worth doing things differently than originally planned.

Project documentation

- [Tallin – Design documentation](#)
- The procurement for preliminary design and detailed project <https://riigihanked.riik.ee/rhr-web/#/procurement/7552644/general-info>
- The procurement for construction <https://riigihanked.riik.ee/rhr-web/#/procurement/8325884/general-info>
- The separate additional construction procurement for installing the vortex-type separator <https://riigihanked.riik.ee/rhr-web/#/procurement/9035384/general-info>

Riga (Latvia): Šmerļupīte catchment

The Riga pilot site focuses on an approximately 800-metre section of the Šmerļupīte stream, where rainwater from a 20 km² catchment area from Mežciems, Pļavnieki, and Dreiliņi neighbourhoods is discharged. The stream has been artificially modified and is partially channelised underground. The incoming stormwater contains high levels of total nitrogen, ammonium, total phosphorus, and organic contamination (BOD₅), as well as elevated levels of lead and copper, indicating possible illegal domestic sewage connections. This pollution degrades the ecological condition of Šmerļupīte and negatively affects the recreational value of the surrounding green zone, which is used by residents for leisure. It also impacts water quality downstream, particularly along the southern shore of Lake Ķīšezers.

The pilot aims to improve water quality and restore the ecological and social value of the area through targeted nature-based stormwater treatment and stream re-naturalisation measures.

Background and initial drivers

The City of Riga participates in the MUSTBE project with the aim of promoting the implementation of nature-based solutions (NBS) in stormwater management and urban planning. Riga's priorities include climate change adaptation, improvement of water quality, and the development of green and blue infrastructure, as well as strengthening urban resilience to flooding and heatwaves.

Local challenges are related to outdated stormwater drainage infrastructure, overloaded systems during heavy rainfall, and pollutants reaching surface water bodies. An additional challenge is **the limited awareness among the public and institutions about the benefits of NBS** and the need to integrate such solutions into urban development processes.

The initial objectives include establishing a pilot area in the Šmerļupīte catchment, where various stormwater treatment and retention measures will be demonstrated, as well as developing a monitoring system to assess the effectiveness of these solutions.

Planning and selection of the pilot area

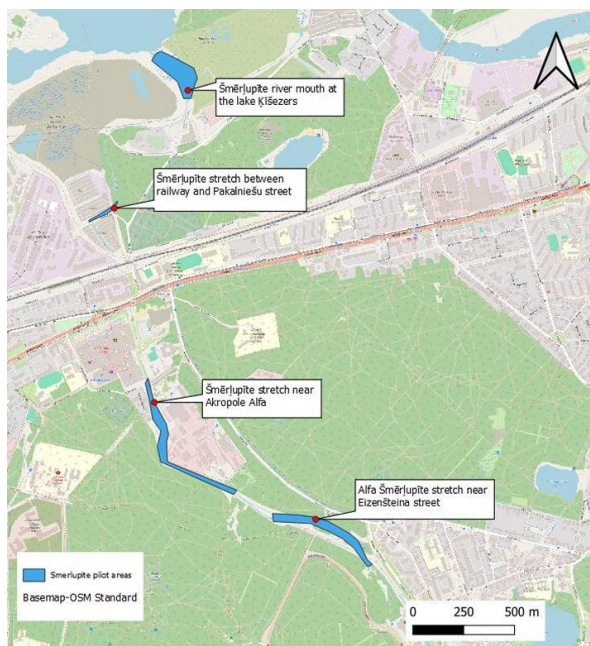
The planning process for the Riga pilot site began with a thorough evaluation of several potential locations along the Šmerļupīte stream, which is a small watercourse collecting stormwater drainage from densely populated urban dwellings and industrial areas.

Selected sections of the stream were assessed using a multicriteria analysis that considered water quality impact, space availability, technical feasibility, biodiversity improvement, recreational potential, and financial aspects.

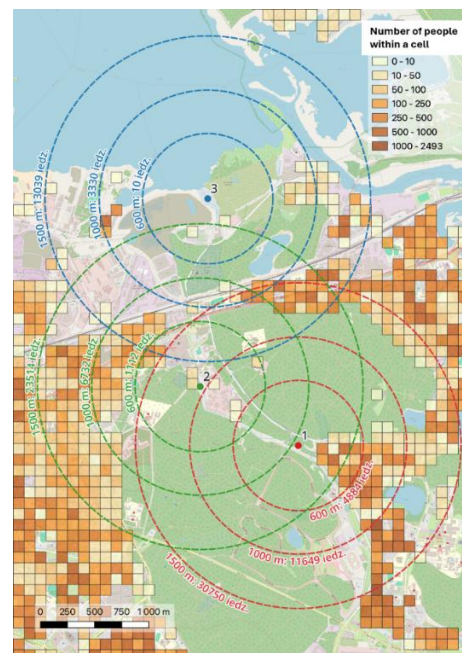
Multicriteria analysis for pilot territory selection:

Criterion	Šmerļupīte river mouth at the lake Ķīšezers	Šmerļupīte stretch between railway and Pakalniešu street	Šmerļupīte stretch near Akropole Alfa	Šmerļupīte stretch near Eizenšteina street
Potential impact on water quality	3 – location in the downstream of the entire catchment	2	2	2
Space availability (municipal land)	3 – large	1	2	3
Technical feasibility	1 – difficult access for construction equipment	2 – rather difficult access for construction equipment	1 – easy access for construction equipment but constrained by sewer reconstruction	3 – easy access for construction equipment
Impact on biodiversity	1	2	2	2
Recreational potential	1	1	3	3
Financial aspects	1	2	2	3
Total	10	10	12	16

Alongside the multicriteria analysis, the potential reach and impact of each proposed pilot site on the surrounding population were assessed using GIS tools and demographic data.



Šmerļupīte re-naturalisation options on municipal land.



Impact on population by the installed NBS at each of the proposed pilot sites on Šmerļupīte stream.

The selected site, located near Eizenšteina Street, offered the best balance of environmental benefit and practical feasibility, scoring highest in the multi-criteria analysis (16 points).



Existing situation in the Riga pilot area.



Initial situation in the selected pilot territory.

Design

Preliminary design

The preliminary design phase focused on identifying the most suitable configuration of nature-based stormwater treatment elements and re-naturalisation solutions. Simulations using EPA

SWMM software assessed stormwater discharge scenarios from two major systems (Purvciems-Teika) and (Dreiliņi-Mežciems) into Šmerļupīte. These models informed the design capacity and flow characteristics.

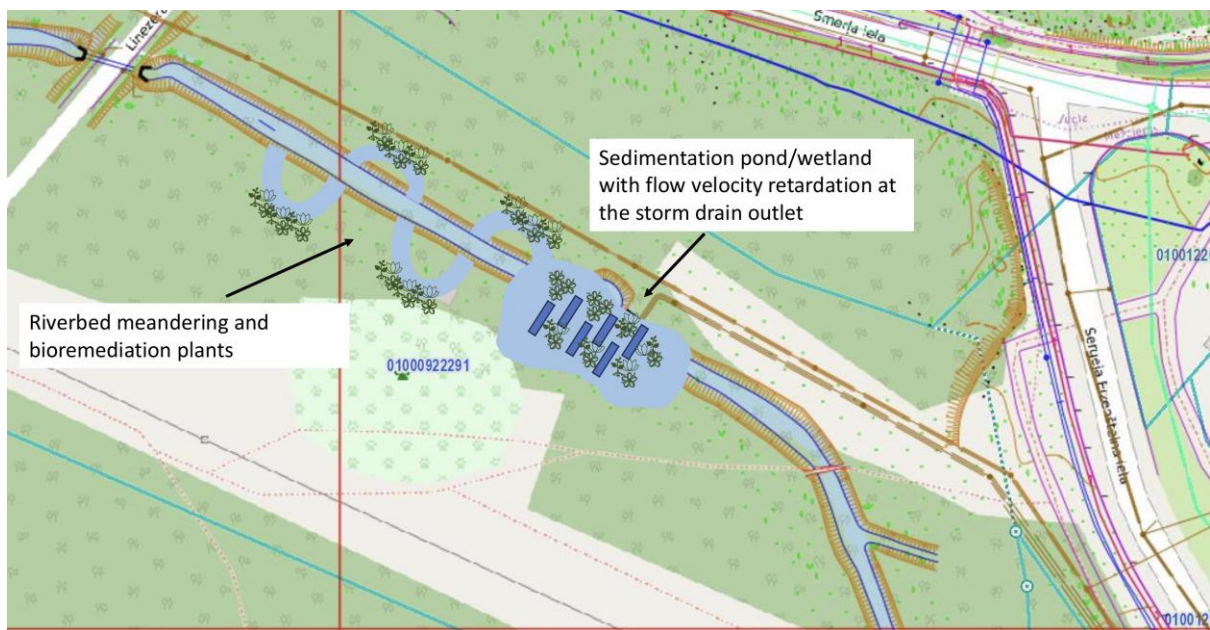
Sampling during dry and rainy conditions revealed elevated levels of COD, BOD₅, suspended solids, nitrogen, phosphorus, and heavy metals, justifying the need for treatment interventions.

Proposed nature-based solutions included:

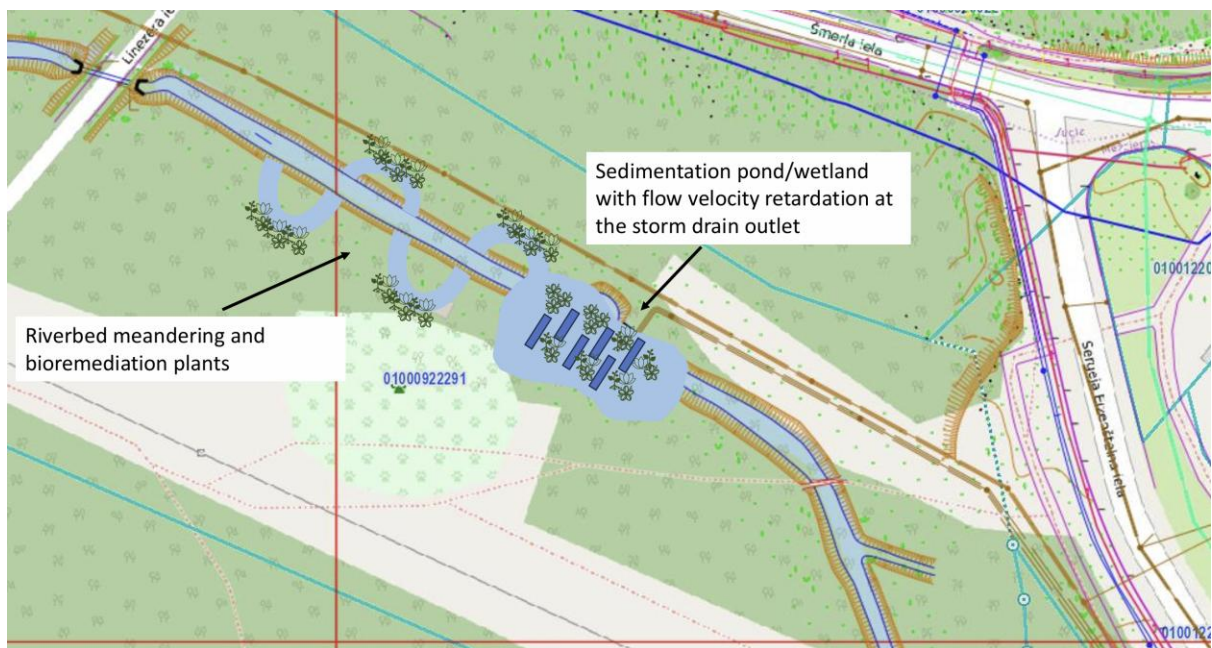
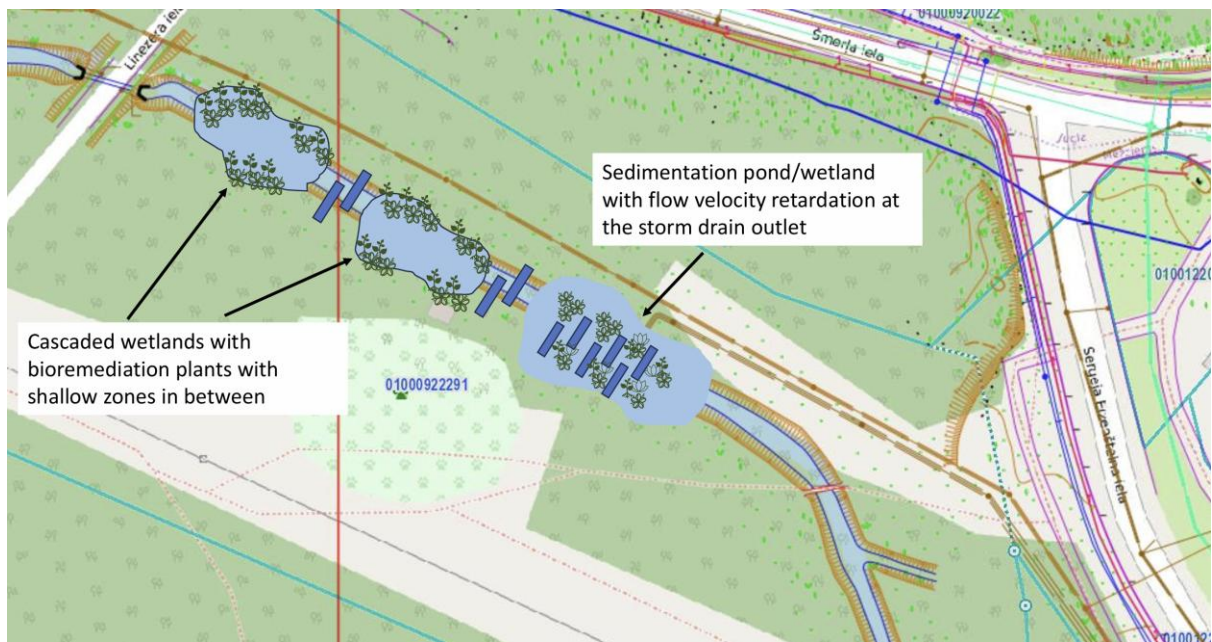
- Meandering of the stream;
- Sedimentation ponds;
- Sedimentation floodplains;
- Cascades;
- Aquatic vegetation for nutrient absorption.

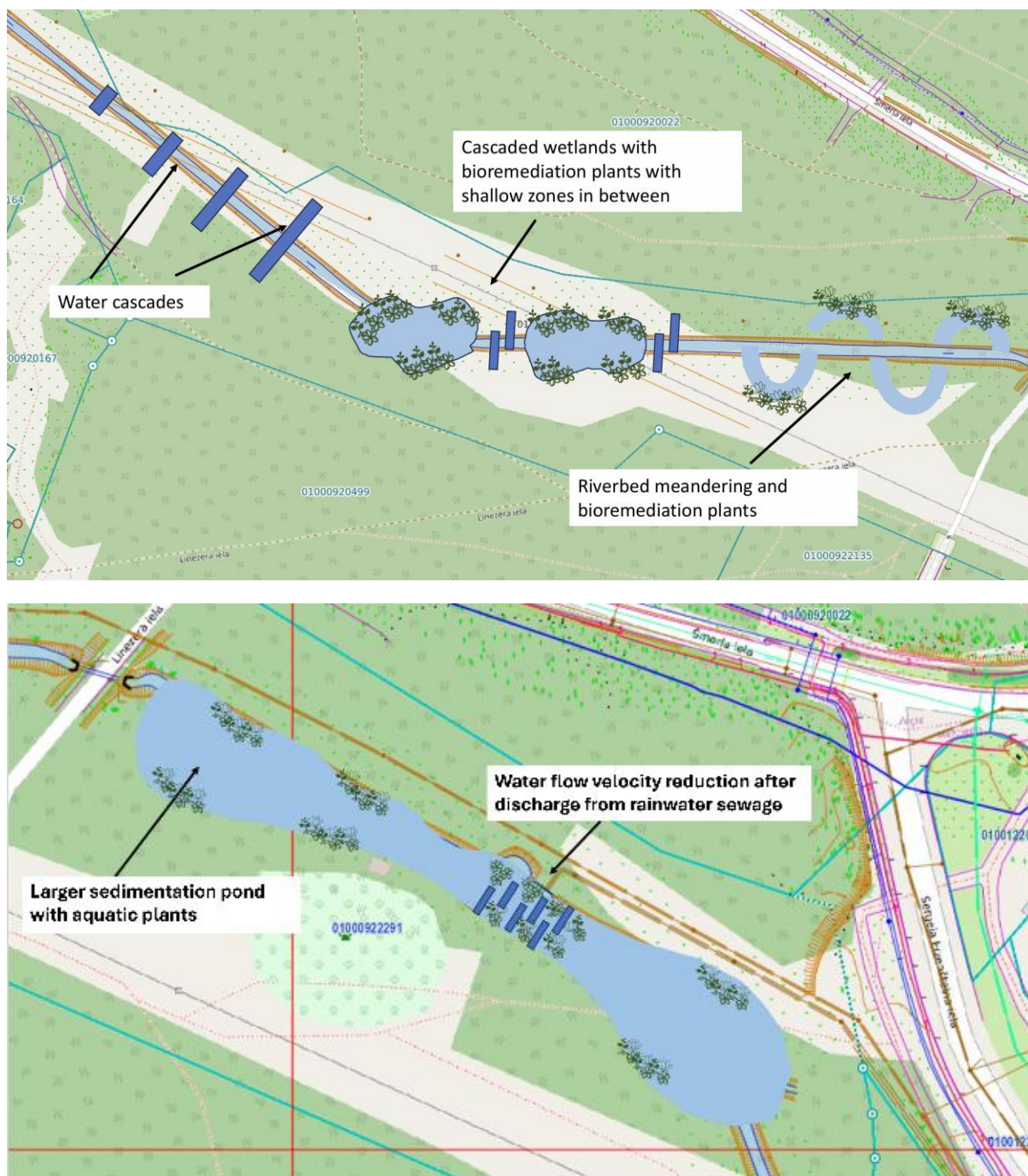
Plans were made to install sensors upstream and downstream of the treatment area to measure turbidity, conductivity, temperature, pH, and flow velocity. Manual sampling would complement sensor data for COD, BOD₅, and suspended solids.

Preliminary designs considered access for maintenance machinery and integration of recreational landscaping to enhance public use.



MUSTBE





Preliminary designs for the Šmerļupīte pilot territory.

Final design

The final design, approved in October 2025, builds upon the preliminary concepts and incorporates detailed technical and landscape elements. Design scope covers an 800-meter section of Šmerļupīte between Eizenšteina and Stūrīša Streets. It divides the area into two functional zones – stormwater treatment zone, which includes sedimentation ponds and reed

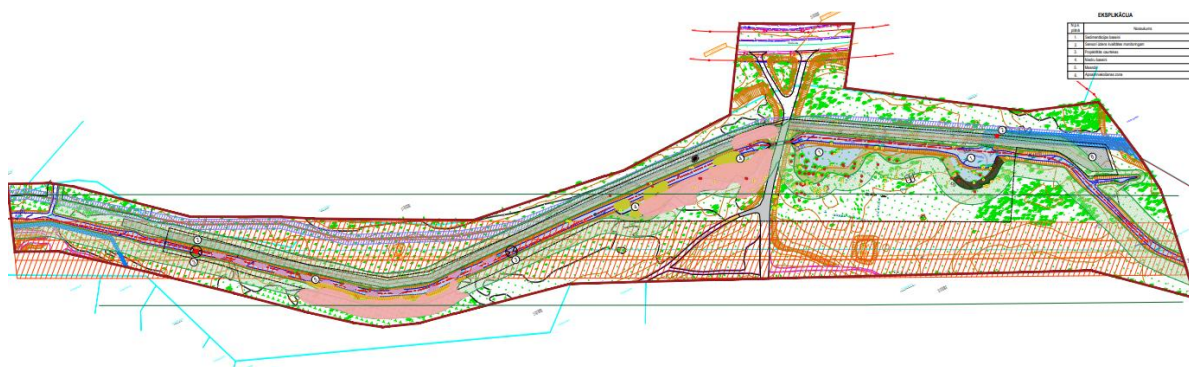
filtration beds, and renaturalisation zone, features meandering stream paths, wet meadows, and phytoremediation vegetation.

Sedimentation and filtration ponds are designed to slow water flow and promote pollutant removal. Vegetation includes species such as *Lolium perenne*, *Cirsium arvense*, *Festuca rubra*, *Trifolium pratense* etc. Wet meadows and two-level riverbanks enhance biodiversity and water quality.

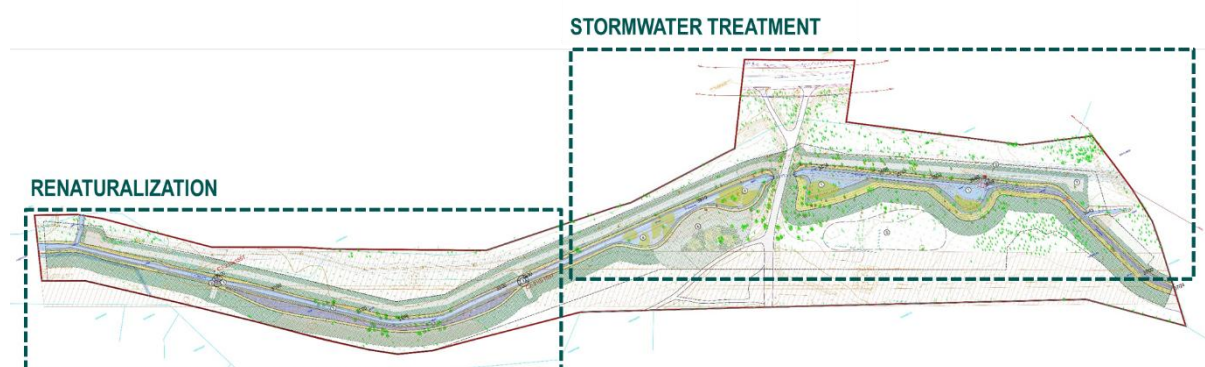
For the monitoring purposes, real-time sensors for pH, EC, temperature, turbidity, and flow velocity are foreseen with telemetry systems for data transmission and integration into online platforms. Manual sampling is planned for comprehensive water quality analysis.

Design ensures access for sediment removal and streambed cleaning. Recreational paths and green zones are integrated to maintain usability and aesthetic value.

The construction tender deadline was on 20 October 2025. Final construction and monitoring system integration are underway.



Designed solution layout plan.



Division into re-naturalisation and stormwater treatment zones.

Procurement and tendering

The procurement process in Riga has been the most challenging influencing factor in this project for several reasons. In Latvia, overall, there is limited experience with such solutions, and the terminology related to nature-based solutions is not yet widely used among designers and contracting authorities. As a result, there are few potential bidders who fully meet the qualification requirements. A review of the database of licensed experts shows that there are very few certified specialists in Latvia with expertise relevant to this field, including those specialising in drainage and water management systems. Furthermore, the procurement process itself is complex and time-consuming. Before each tender, extensive market research must be conducted, and if no bids are received during that stage, the procedure has to be repeated. The City of Riga follows a strict internal procurement procedure overseen by the Legal Department, which ensures compliance but also means that it is not possible to shorten or skip any of the required steps.

Implementation

The design was approved in October 2025, and the construction will begin in November 2025.

Reflections

One of the key challenges during the planning and design phase was **the limited experience with nature-based solutions among both designers and the institutions responsible for permitting and coordination**. The Riga pilot site project received numerous clarifying questions from authorities, which significantly slowed down the approval process. In the Building Information System (BIS), each additional inquiry can delay progress by one to two weeks. Upon review, many of these questions were found to be clarifications that could have been addressed later during the author supervision phase, rather than delaying design approval.

The Riga team had already identified risks related to the project timeline during the preparation stage, particularly due to the municipality's strict procurement procedures. For future projects, allocating more time for coordination and approvals will be essential.

Overall, the experience gained through the MUSTBE project has contributed to a more systematic approach to NBS implementation in Riga. Lessons learned have been integrated into the city's Greening Plan and Climate City Contract, potentially helping to streamline future planning and permitting processes and making it easier to implement similar nature-based solutions at the municipal level.

Project documentation

- [Riga – Design documentation](#)

Söderhamn (Sweden): Söderhamnsporten

Söderhamnsporten is one of two pilot sites simultaneously implemented in Söderhamn aimed at sustainable management of stormwater and improved biodiversity in urban and coastal areas. The Söderhamnsporten pilot site is located in the vicinity of the new transportation hub that combines rail- and highway junctions, and connections to the centre of Söderhamn. Recent construction activities and increased traffic volumes have led to a significant rise in impermeable surfaces, posing challenges for stormwater management. Over the past decade, the area has experienced recurring flooding events, highlighting the urgent need for improved and sustainable stormwater solutions.

The Söderhamnsporten pilot area focuses on proactively managing stormwater through a meandering water channel that reduces peak flows and improves water quality before discharge into the Söderhamnsån River with the use of a combination of sensors and nature-based approaches.

Background

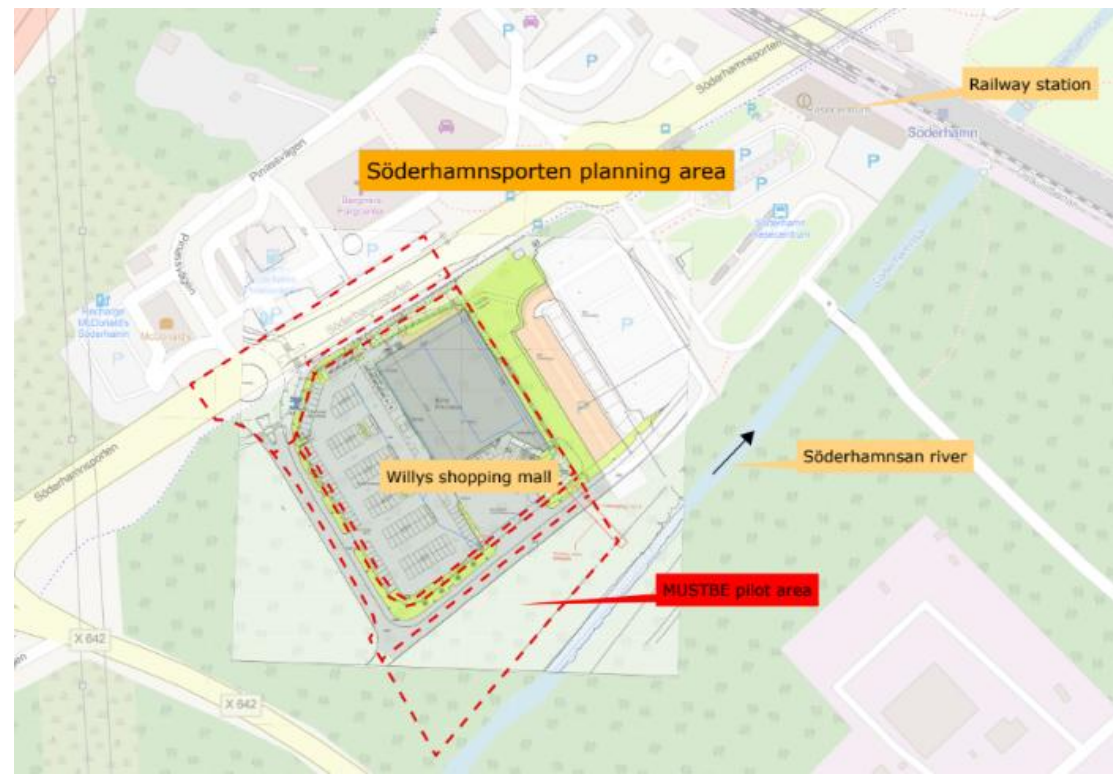
Stormwater planning in Söderhamn was initially driven by the impacts of a major rainfall event in 2013, which caused flooding in several urban areas. Since 2015, the municipality has actively advanced stormwater management through Interreg projects, focusing on reducing pollution and flood risks. In Söderhamnsporten, careful planning is especially important due to the site's proximity to the Söderhamnsån River, which has experienced flooding over the past decade.

Stormwater management is critical to maintaining the water quality of the Söderhamnsån River, which receives untreated runoff from approximately 1 ha of impervious surfaces, including the parking lot (ca 0.7 ha) and roof (ca 0.3 ha) of a relatively newly built supermarket. As the area is expected to undergo significant development in the future, with new buildings, streets, and parking lots, the pilot is especially significant in showcasing nature-based solutions tailored to local challenges, offering insights into planning, implementation, and community impact.

The pilot site was selected as the pipe network in the area was old and in need of renovation. In addition, while the surrounding area will undergo further development, the pilot area in question was finished, making it easier to plan and design a solution for it. There was also a need to manage the stormwater in the area as prior to the implementation of the pilot, the area's stormwater was discharged directly into the river without any form of treatment or retention.



Pilot area before construction.



Location of the solution.

Previously, stormwater from the parking area flowed across the surface into underground drainage, which collected and conveyed the water into a 400 mm main collector located beneath the municipal road. The collector discharged on the opposite side of the road, where the water flowed into the river via a straight, excavated ditch.

Preliminary runoff modelling indicates a peak flow of 290 l/s during a 10-year storm event with a 10-minute duration and rainfall intensity of 121 mm/h. Theoretical pollutant concentrations, based on the StormTac database, are estimated at 174 mg/l for suspended solids (SS) and 2.3 mg/l for total nitrogen (Tot-N).

Planning

The planned solution aims to reduce suspended solids (SS) and total nitrogen (Tot-N) concentrations at the outflow to below 105 mg/l and 1.4 mg/l, respectively. Additionally, peak flow rates are targeted to return to pre-development levels, estimated at 61 l/s based on preliminary modelling. To achieve these goals, a 200 m³ retention facility was proposed to help manage flow velocity and improve water quality before discharge into the environment.

Design

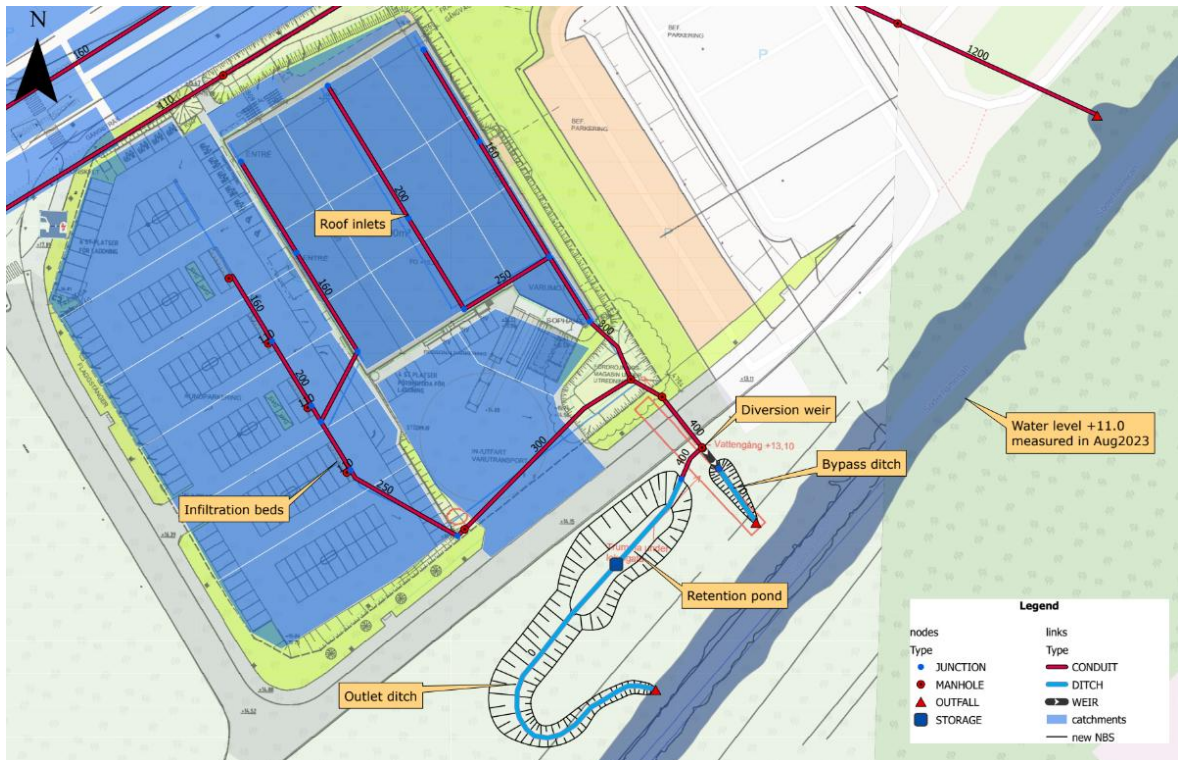
Collaboration with TalTech led to the design of a meandering water channel – a snake-shaped open stream that winds upstream toward a dam and then flows back into a stream before discharging into the Söderhamnsån River. This nature-based design aims to reduce peak flow and increase retention time, thereby improving the purification of stormwater.

Most of the stormwater runoff from the catchment area is directed through a diversion manhole to the meandering water channel. The channel is planted with resilient greenery capable of withstanding rapidly changing conditions, such as droughts and floods, while also contributing to nutrient removal from the stormwater. To support sedimentation, the pond section near the inlet was designed to be wider and deeper, encouraging particles to settle. The outflow is naturally restricted using landscaping elements like boulders, which help maintain sufficient retention time.

The pond is also designed to blend into the landscape year-round, including during droughts and winter, with vegetation planned even at the bottom of the excavation to ensure visual and ecological continuity. Herbal grass was chosen instead of meadow grass to consider the ease of maintenance as meadow grass has to be cut down several times a year. In addition, herbal grass can be walked on without it being damaged while providing similar biodiversity benefits to meadow grass.

In addition to retention and purification, the pond allows for partial filtration of retained water. In the event of extreme rainfall (e.g. a 100-year storm), the diversion manhole with a weir

activates and directs excess water to a bypass ditch, managing overflow and preventing flooding in the area.



Designed NBS solution with the designed parking lot pipe system.



Designed solution layout plan.

The design process took a long time as the plan passed between the planning and drawing departments several times within the municipality of Söderhamn. The plan also had to be redone due to these issues which slowed down the process. The second pilot site of Söderhamn, Broberg, was also large and more complex resulting in Porten's design work being overshadowed and progressing slower.

Procurement and tendering

Due to various factors, the contracting discussions coincided with the summer season, a period with tight time constraints, prompting the use of alternative approaches to advance the framework agreement for land contracts. After receiving the preliminary offer, cost negotiations were necessary, mainly focused on maintenance and warranty periods, tree planting, and excavation material handling. Throughout this phase, flexibility was key to keeping the project on track despite seasonal and budgetary pressures.

Implementation

The design process for the Söderhamnsporten pilot was straightforward, with no major changes during the technical phase. However, it took longer than expected due to the need to align with the planning and processes of the second Söderhamn pilot (Broberg, see next chapter), which limited the available time for implementation. Construction of the Söderhamnsporten pilot began in August and was completed in November 2025.





Porten pilot site during construction in October 2025.

All in all, the construction works went smoothly. The only issue was the late season as the wet ground would have caused possible issues, such as rotting, with the newly planted vegetation. The plantings of the vegetation were therefore moved to spring 2026 to better ensure good growth conditions. There is also a one-year plant warranty that requires the contractor to replace any failed plants without additional cost.

A new detailed plan for the surrounding area is also being developed that will visually and functionally integrate with the MUSTBE pilot's stormwater management solution.

Reflections

Implementation of the Söderhamnsporten pilot progressed smoothly overall, but the project also revealed several important lessons for planning, design, coordination, and long-term management of nature-based stormwater solutions.

A key challenge throughout the process was the complexity of the design phase, which took longer than anticipated. The design shifted between the municipality's planning and drawing departments multiple times, requiring revisions and delaying progress. Coordination with the parallel Broberg pilot added further pressure, as that site was larger and more complex and consequently drew more attention and resources. The experience also highlights the importance of thoroughly understanding local conditions, such as groundwater levels and pollution risks, before selecting the final site for construction, as these factors can significantly affect both cost and complexity. In general, the pilot project would have benefitted from more people with substantive experience, such as construction.

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On the procurement side, the tendering process coincided with the summer season, creating tight time constraints. As a result, the municipality needed to adopt flexible approaches to keep the framework agreement moving forward. Negotiations, particularly around warranty periods, planting, and material handling, were crucial to maintain quality within the available budget. This demonstrates the value of early scheduling and recognising how seasonal constraints affect procurement and construction. Despite delays in design, the construction phase itself proceeded efficiently. Few issues arose during implementation, although the late season created challenges for the plantings. To ensure optimal growth conditions and reduce risks such as plant rot in wet autumn soils, planting was postponed to spring 2026.





Completed pilot site in December 2025.

Anchoring the project within the organisation and building consensus around key measures proved essential for progress. Collaboration with expert partners was highly valuable, and maintaining strong working relationships is strongly recommended. The solution would have benefited from more time for monitoring treatment efficiency within the project timeline, especially in Nordic climates, where sensor performance can be affected by freezing temperatures during winter.

Finally, the pilot demonstrates the broader benefits of integrating NBSs into urban development. As the surrounding area continues to develop, additional green and stormwater-oriented spaces are planned, reinforcing the role of NBSs in creating attractive, resilient urban environments. The Söderhamnsporten pilot not only improves stormwater management but also enhances recreational value and overall appeal of the area. The outcome is satisfactory and the pilot is viewed as an important reference point for future stormwater planning in Söderhamn.

Project documentation

- [Söderhamnsporten – Design documentation](#)

Söderhamn (Sweden): Broberg

Broberg is one of two pilot sites implemented simultaneously in Söderhamn, with the goal of managing stormwater and enhancing biodiversity in both urban and coastal environments. Located in a coastal district, the Broberg site is vulnerable to sea-level rise and flooding. The area is currently undeveloped and consisting mostly of natural surfaces, but planned residential development will introduce new stormwater pressures, including increased loads of suspended solids and nutrients.

Broberg is located in a low-lying coastal area where water naturally accumulates, making stormwater management a central focus of the pilot. The project aims to ensure proper stormwater treatment and construct a new outlet to Söderhamn's bay, addressing both current and future runoff pressures. The catchment area is around 17 ha which is under planning phase. The district is situated at the Söderhamn's bay, covered with mostly natural surface and is highly affected by the sea-level. To address these risks, the pilot aims to implement sustainable, multi-functional stormwater solutions that not only improve resilience and protect water quality in the Baltic Sea but also contribute to the creation of usable public space that supports ecological and social value.

The design of the Broberg pilot includes a combination of ditches, small ponds, and two retention areas to retain and treat the stormwater, as well as a new culvert and outlet pipe equipped with a backflow valve to manage discharge to the bay. The design also includes an a monitoring manhole, enabling performance tracking.

Background

The site presented several challenges, including high groundwater levels, sulfidic clay soils, fluctuating sea levels, ageing stormwater infrastructure, old railways and heritage-listed buildings. Additionally, the area previously lacked sufficient retention volume to manage extreme weather events.

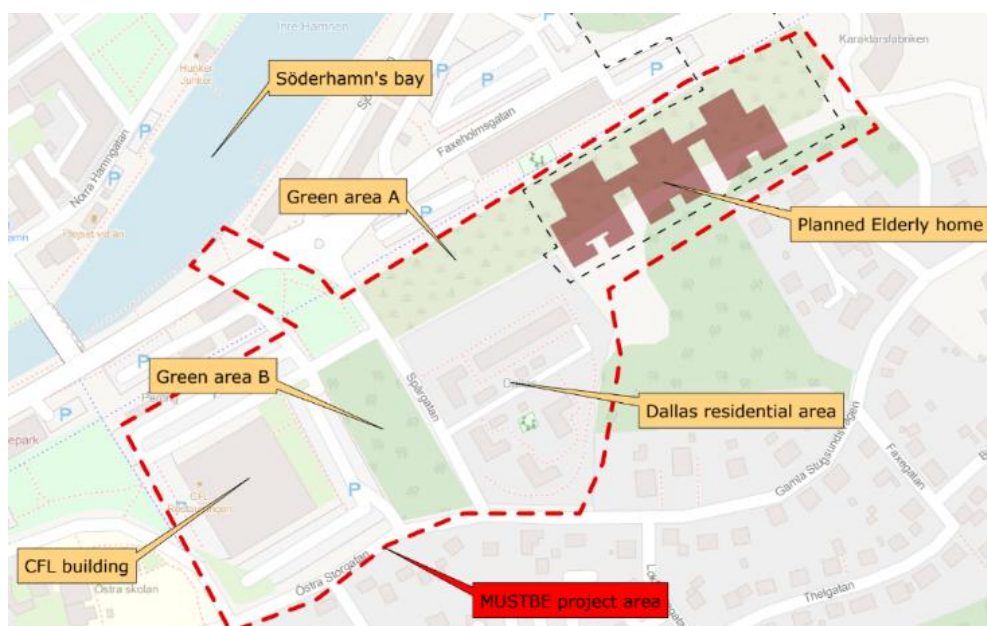
A new residential home has been planned directly above the location of the previous stormwater outlet pipe, significantly increasing impervious surfaces such as roofs and parking lots. This development intensified the need to upgrade the stormwater system to accommodate larger volumes. The previous outlet pipeline was also in poor condition and partially located beneath existing buildings, posing a risk of pluvial flooding if the system fails.

According to preliminary studies, peak runoff from the development area is expected to reach 320 l/s. Runoff modelling for a 10-year storm event (15-minute duration, 89 mm/h intensity) estimates a peak flow of 180 l/s from the area to the sea, accounting for all planned developments. Theoretical pollutant concentrations, based on the StormTac database, are estimated at 88 mg/l for suspended solids (SS) and 1.3 mg/l for total nitrogen (Tot-N).

Planning

In Broberg, there has been a strong political will to make the area usable for citizens, which required a thorough analysis of stormwater runoff systems to address risks posed by sea-level rise, flooding, and ageing infrastructure. Geographically the area is also in excellent location, and higher authorities had also hoped that something would be done about the stormwater in the area.

Before the implementation of the pilot solution, the stormwater from nearby parking areas, the roof of Centrum för Flexibelt Lärande (CFL), and the northern part of the Dallas district was conveyed to green area B, and from there through a culvert to a ditch in area A on the opposite side of Spårgatan Street. This ditch also received runoff from the rest of Dallas and channelled all water to a downstream pipeline that discharges at the shore of Söderhamn's bay. During planning, it was also discovered that stormwater was causing flooding issues in the basement of the CFL building due to issues with the previous stormwater outlet pipe, underlining the need for upgrading.



Neighbourhood area conception. The planned elderly home in the picture has since been changed to a residential home.

During planning, it was identified that green area B and the ditch in area A lack sufficient retention volume to manage extreme weather events. Complicating matters, a new residential home was planned directly above the location of the previous stormwater outlet pipe, which would significantly increase impervious surfaces and runoff volumes. The previous stormwater infrastructure was not designed for water purification, and the culvert between areas A and B sat approximately 0.5 meters below the invert levels of the upstream and downstream ditches.

This misalignment had led to sediment accumulation, reducing the culvert’s capacity and further limiting system performance.

The smart nature-based solution designed for the Broberg area aims to reduce suspended solids (SS) and total nitrogen (Tot-N) concentrations at the outflow to below 53 mg/l and 0.8 mg/l, respectively.

Design

Although the Broberg area had been studied for several decades, stormwater management had not been adequately addressed until the project. During the planning phase, TalTech highlighted the challenges of managing large volumes of stormwater in this location, particularly due to the presence of sulphidic clay and high groundwater levels, which complicate construction and infiltration. The preliminary technical design and other materials prepared by TalTech was further developed by a design company for the final design.

A final design was agreed upon that meets the needs of both the municipality and the MUSTBE project, serving as a partial solution in an area where stormwater infrastructure can be further developed over time. The pilot features a combination of ditches, small ponds, and two retention areas to retain and treat stormwater.



Designed solution layout plan for retention areas A and B.

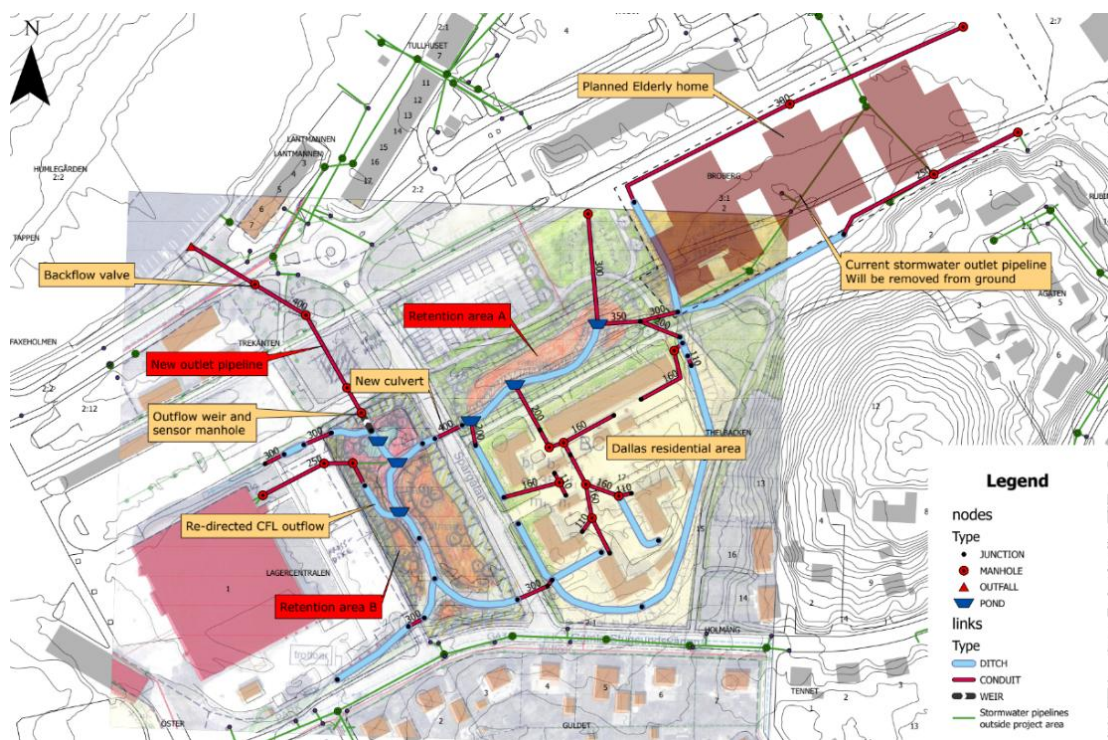
The retention ponds foster sedimentation and nutrient removal with landscaping objects such as boulders and vegetation ensuring sufficient retention time. The possible presence of sulphide soils and high groundwater level of the area posed some limitations to the design as the city would have liked the retention ponds to be deeper and larger.

A new culvert and outlet pipe equipped with a backflow valve was also installed to manage discharge to the bay. The new outlet pipeline mitigates the risk of stormwater pipe network failure and further supports the management of excess stormwater volumes, which is essential to improving the current situation and enabling future development. Compared to the previous situation where runoff water flowed from green area B to green area A, the Broberg pilot solution aimed to reverse the direction.

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To ensure system resilience and safety, the design also includes an overflow weir and a monitoring manhole, enabling performance tracking and emergency overflow management. The solution aims to balance technical functionality with ecological and recreational value, contributing to long-term sustainability in the coastal district.



Stormwater management solution.

The design also includes a monitoring manhole, enabling performance tracking. The solution aims to balance technical functionality with ecological and recreational value, contributing to long-term sustainability in the coastal district.

Procurement and tendering

The overall project budget was exceeded during the procurement process, prompting cost-reduction negotiations. Ultimately, additional funding from the municipality was allocated, allowing the project to move forward as planned.

Implementation

The technical design phase required significantly more time than initially anticipated, which resulted in a compressed timeline for the implementation stage. To mitigate potential conflicts, close coordination was maintained with other ongoing infrastructure activities in Broberg, including grading and laying of new asphalt. Construction of the Broberg pilot began in August and was completed in November 2025.

Sulphidic soil and groundwater level had to be considered when excavating the land. Many soil samples were taken before the excavation work began to avoid exposing sulphidic materials to oxygen. Although, as sulphidic soil is found very sporadically in Söderhamn, the soil samples

could not show the whole picture and thus, it was only during the excavation work that the reality of sulphidic soil locations would have been seen.

If groundwater or sulphidic material had been present, the construction work would have had to stop, the area covered and samples sent for analysis. Fortunately, no groundwater or contamination issues were uncovered during the excavation work. As the locations of sulphidic soils are very difficult to determine before excavation, one must constantly be vigilant to see if there are signs of sulphidic material, i.e. bad smell, bluish or black soil, during the works.



Construction works in Broberg in September 2025.

Challenges during the construction project were caused by the fact that the technical design was based on the given drawings, which did not fully match reality. As the work progressed, some changes had to be made to the original design when it was noticed that things were not as planned in practice. For example, the depth of the pipes in the ground had to be changed, as some pipes were placed too close to the surface and some pipes too deep. In addition, when deviations from the initial plan occurred during the construction phase, the drawings should have been updated based on the changes made – this was not always done, and some information remained in the drawings that was not entirely correct.

The planting of the vegetation was completed the following spring to better ensure good growth conditions as the late fall and wet ground would possibly have caused the roots to rot.



Implementation works on the pilot site.



Construction works during October 2025. Green area B is in the forefront.

Reflections

The Broberg pilot encountered several challenges stemming from the complexity of the site and the varying requirements of stakeholders. These factors contributed to delays in finalising the technical design for both Söderhamn pilots.

Several challenges stemmed from difficult local conditions, especially high groundwater levels, sulphidic soils, and mismatches between drawings and on-site reality, which contributed to delays in finalising the design and required adjustments during construction. These experiences highlight the importance of thoroughly understanding site-specific conditions early in the process, as groundwater and soil properties can strongly influence both feasibility and cost of implementation.

One major success was the upgrade of the stormwater outlet pipe at the CFL building as prior flooding in the basement has not recurred since the pilot’s implementation. At the same time, several lessons emerged from the accelerated planning and design phases. Rushing the process meant that some design details were overlooked, resulting in fixes during and after construction such as adjusting pipe depths and adding stones to retention ponds to prevent erosion. In hindsight, leaving a larger part of the area untouched could have preserved more natural landforms, as extensive soil removal led to steep pond banks and increased erosion risk. More comprehensive modelling of the entire area would have helped foresee these impacts. It was also challenging to engineer the natural flow of water as part of the solution was reversing the flow of water from flowing from green area B to area A to flowing from green area A to area B.



Completed pilot site in December 2025. Green area B is shown in the forefront.

Other structures, such as trees and small walkways, will be added to the pilot site later to increase the recreational use of the area. In addition, more nature-based solutions are likely to be planned in the surrounding area.

Not all wishes could be taken into consideration during the planning phase. For example, the municipality would have wanted to make the retention ponds deeper and larger, but the high groundwater level and possible sulphide soils prevented this.

One notable limitation was the restricted timeframe available for monitoring and analysing the solution's effectiveness. In Nordic climates, seasonal constraints, especially the risk of sensor freezing during winter, can hinder data collection and affect the reliability of results. Allowing more time for monitoring during the project would have enhanced the evaluation of treatment performance and long-term impact.



Completed pilot site in December 2025.

Establishing a strong organisational foundation and achieving consensus on proposed measures proved to be essential for project momentum. The collaboration with expert project partners was particularly valuable, and the importance of cultivating and maintaining positive working relationships cannot be overstated.

Project documentation

- [Broberg – Design documentation](#)

Key implementation principles for GIS databases

According to D.1.1.1-GIS database with spatial information, the availability of good quality, up-to-date and harmonized spatial data is the foundation for reliable data-based decision support systems in the urban water sector. The document highlights that water utilities and municipalities in Europe are still lagging behind in implementing standardized digital solutions and harmonized data management approaches.

Effective GIS implementation requires:

- clear institutional cooperation between municipalities and water utilities,
- agreed minimum data requirements for stormwater systems,
- continuous data sharing and updating procedures,
- harmonization of datasets across departments and organizations.

In decentralized systems (e.g., where different departments manage pipes, ditches, open water bodies, or surface infrastructure), lack of coordination leads to fragmented datasets and limits integrated urban water management. Therefore, cross-organizational working groups and structured communication protocols are essential.

D.1.1.1 stresses that GIS databases must be designed not only for spatial storage of infrastructure, but also to support:

- hydraulic modelling,
- development of digital twins,
- system performance analysis under different operational conditions,
- investment scenario comparison,
- long-term lifecycle planning of stormwater infrastructure.

A properly structured GIS database enables integration of elevation data, network topology, asset attributes, maintenance records, and monitoring information, forming the technical backbone for urban stormwater decision-making.

Assessment of pilot solutions

As part of the MUSTBE project, a multi-objective analysis combined with cost-benefit assessment was used on the pilot solutions to evaluate and select optimal technical solutions for stormwater treatment.

The report integrates results from previous activities (GIS database and digital twins) and applies modelling tools (SWMM-based digital twins) to assess the environmental, hydraulic and socio-economic performance of planned nature-based solutions (NBS).

Multi-Objective Analysis

The multi-objective analysis evaluated trade-offs between:

- flood reduction,
- water quality improvement,
- cooling (urban heat reduction),
- public health and well-being benefits.

Each pilot area was divided into a 10 m × 10 m grid. For each grid cell, impacts were calculated and normalized (0–1 scale) and converted into scores (1–4).

Flood reduction was modelled using SWMM simulations. Water quality improvement was calculated based on expected reduction of total suspended solids (TSS) and nitrogen. Cooling effect was estimated based on land-use dependent temperature reduction rates. Well-being impact considered landscape functionality, population density (600 m radius) and added public space value.

Total benefit scores (multi-objective analysis):

- Viimsi – 10;
- Tallinn – 8;
- Söderhamn 1 (Porten) – 7;
- Söderhamn 2 (Broberg) – 9;
- Pori 1 (Central Square) – 5;
- Pori 2 (Wetland) – 14;
- Riga – 14;

Highest multidimensional impact: Pori 2 (Wetland) and Riga.

Cost–Benefit Analysis (CBA)

A 30-year Net Present Value (NPV) analysis was conducted with 3% inflation rate.

The CBA considered:

- Investment costs (based on project budget);
- Maintenance costs (annual);
- Replacement cycles (10-year interval for smart equipment);
- Area-based benefit valuation (EUR/m²);
- Water quality benefits converted from mass reduction (EUR/kg).

Cost-Benefit Ratio (BCR) results:

Pilot	BCR
Viimsi	1.85
Tallinn	1.01
Söderhamn 1	1.64
Söderhamn 2	3.64
Pori 1	1.07
Pori 2	3.83
Riga	3.56

All pilots have BCR > 1, meaning that benefits exceed costs over the 30-year period.

Highest economic performance:

- Pori 2 (Wetland) - 3.83;
- Söderhamn 2 (Broberg) - 3.64;
- Riga - 3.56.

Key Technical Characteristics of Selected Solutions

Based on the combined multi-objective and economic assessment, the following NBS configurations were selected:

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- Viimsi – stormwater retention pond, rain garden system and fountain-based reuse.
- Tallinn – pond and bioswale system with weirwall for automated flow diversion.
- Söderhamn 1 – retention pond and meandering ditch with real-time sensors.
- Söderhamn 2 – dual retention and treatment areas with monitoring sensors.
- Pori 1 – urban greenery solution integrated into a parking area.
- Pori 2 – wetland with filtration dams (biochar, gravel, pumice stone, limestone) and real-time water quality monitoring.
- Riga – treatment wetland and renaturalized creek with sensor-based monitoring.

Preliminary technical designs were prepared for each site to proceed to detailed design and construction.