Degree Project in Environmental Engineering and Sustainable Infrastructure

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Assessment of the Triggers for Excessive Filamentous Algal Growth in Stormwater Ponds and Preventive Management

Study cases in Uppsala

MARGARITA JUDINA AND MONICA A. VARGAS-SOLLA

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Cover photo: Pond in Elsa Eschelssons Park, Rosendal, Uppsala. Photo by Margarita Judina

Authors: Margarita Judina, Monica A. Vargas-Solla

Supervisor: Sahar Dalahmeh, Docent, Senior Lecturer at KTH Royal Institute of Technology

Examiner: Prosun Bhattacharya, Professor, KTH Royal Institute of Technology

TRITA – ABE – MBT –25632
Stockholm, Sweden 2025
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Abstract

In Uppsala Municipality, several stormwater ponds (SWP) have been reported to suffer from recurring excessive filamentous algae (FA) growth, raising concern for the aesthetic appearance and the long-term maintenance of these structures. This thesis investigates the factors contributing to excessive FA development in four SWP compared with a reference pond with no reported algal issues. The study integrates field observations, communication with experts, water and algae sampling, laboratory analysis, and literature review to explore relationships between water quality, pond design, environmental triggers, and algal proliferation.

Key water quality parameters, such as nutrient concentrations and pH, were analysed alongside structural features and usual maintenance of each pond. Results suggest that excessive algal growth is not attributable to a single factor but arises from complex interactions between physical design, nutrient loading, ecological dynamics, and human management. In particular, high nutrient availability, low presence of macrophytes, and some physical features were associated with FA dominance. Species identification also highlighted differences in algal composition between sites, with Cladophora and other green filamentous taxa present in impacted ponds.

While the findings provide valuable insights, the study was limited by a short sampling period, low frequency of sampling and difficulties in communication with some stakeholders, as well as variability in pond age, design, and catchment characteristics. These factors introduce uncertainty, particularly in understanding temporal patterns of excessive algal proliferation and maintenance actions taken for each pond. Nonetheless, the assessment offers valuable observations aimed to potentially reduce algal growth in SWP, including consideration of nutrient input, vegetation buffers, and adaptive maintenance strategies, both technical and social.

The thesis underscores the importance of integrating ecological understanding into the design and maintenance of SWP. Since excessive FA growth results from the complex interactions between biogeochemical and anthropogenic processes, addressing it requires a holistic and site-specific management approach. This study contributes to the growing knowledge base needed for more resilient and sustainable urban water infrastructure.

Keywords
Stormwater management, stormwater ponds, filamentous algae, eutrophication, sustainable urban water management, nutrient retention, algae control, stormwater pond design, urban infrastructure.

Sammanfattning

I Uppsala kommun har flera dagvattendammar rapporterats ha återkommande problem med tillväxt av filamentösa alger (FA), vilket har skapat bekymmer för både dammarnas estetiska utseende och deras långsiktiga underhåll. Denna masteruppsats undersöker faktorer som bidrar till överdriven FA-utveckling i fyra dagvattendammar, jämfört med en referensdamm utan noterade algproblem. Studien kombinerar fältobservationer, provtagning av vatten och alger, laboratorieanalyser samt litteraturstudier för att belysa sambanden mellan vattenkvalitet, dammutformning, miljömässiga faktorer och algtillväxt.

Viktiga vattenkvalitetsparametrar som näringsämneskoncentrationer och pH analyserades i relation till varje damms fysiska utformning och underhållshistorik. Resultaten visar att överdriven algtillväxt inte kan förklaras av en enskild faktor, utan uppstår genom komplexa samspel mellan fysisk utformning, näringsbelastning, ekologisk dynamik och mänsklig påverkan. Framför allt observerades en koppling mellan hög fosforhalt, låg förekomst av makrofyter, och vissa fysiska egenskaper var associerade med FA-dominans. Artsammansättningen skiljde sig också mellan dammarna, där Cladophora och andra gröna trådalger identifierades i de mest påverkade dammarna.

Studien begränsas dock av låg provtagningsfrekvens och variationer i dammarnas ålder, utformning och avrinningsområden samt svårigheter i kommunikationen med vissa intressenter. Dessa faktorer introducerar osäkerheter, särskilt när det gäller att förstå algtillväxtens tidsmässiga variationer. Trots dessa begränsningar ger utvärderingen värdefulla preliminära rekommendationer för förbättrad dagvattenhantering, inklusive aspekter som vattendjup, skyddszoner med vegetation och adaptiva underhållsstrategier.

Uppsatsen understryker vikten av att integrera ekologisk förståelse i utformningen och skötseln av dagvattendammar. Överdriven FA-tillväxt speglar ett komplext samspel mellan biogeokemiska och antropogena processer, och för att åtgärda detta krävs ett holistiskt och platsspecifikt underhåll. Denna studie bidrar med kunskap som kan stödja en mer motståndskraftig och hållbar urban dagvatteninfrastruktur.

Nyckelord
Dagvattenhantering, dagvattendammar, filamentösa (trådformiga) alger,

övergödning, hållbar urban vattenhantering, näringsretention, algkontroll, dammutformning, urban infrastruktur.

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List of abbreviations

FA	Filamentous algae/alga
FTW	Floating treatment wetlands
HAB	Harmful algae bloom
N	Nitrogen
NH_4^+	Ammonium
NO_2^-	Nitrite
NO_3^-	Nitrate
P	Phosphorous
PO_4^{3-}	Orthophosphate
SDI	Shoreline development index
SWP	Stormwater pond/ponds
TN	Total nitrogen
TP	Total phosphorus

List of terms

Allelopathy	An organism’s ability to produce and release chemicals that have inhibitory influence on other organisms growth and reproduction.
Aspect ratio	The ratio of a pond length to its width (L:W)
Benthic	Bottom-dwelling; also can relate to the processes that occurs at the bottom of the water body
Bioturbation	The physical movement induced in sediment by the moving organisms, e.g. fish
Harmful algal bloom (HAB)	Excessive growth of algae or cyanobacteria in the water bodies that can cause release of harmful toxins or lead to oxygen depletion in the deeper part of the water column due to the decomposition of organic matter; often a symptom of eutrophication
Littoral	Near-shore dwelling; related to the near-shore shallow zones
Metaphyton	Free-floating, filamentous algal mats
Mineralisation	Decomposition or oxidation of chemicals found in organic matter into inorganic compounds that are available for intake by photosyntesising organisms
Shoreline Development Index (SDI)	Relation between the perimeter of the constructed water body and a circle with the same surface area

CONTENTS

1 Introduction

Nature-based solutions (NBS) can play a crucial role in mitigating the impacts of climate change, adapting to shifting weather patterns, and supporting sustainable stormwater management (Naturvårdsverket, 2021). In urban areas, stormwater management is becoming increasingly important due to the rising risk of flooding caused by extreme weather events, which can lead to significant economic losses and infrastructure damage, particularly as cities continue to densify. Open stormwater systems have the potential to serve as multifunctional solutions that not only regulate water flow and improve water quality but also help mitigate the effects of heatwaves (European Environment Agency, 2021).

Stormwater ponds (SWP) are widely used nature-based solutions for managing runoff. Beyond their technical function, these ponds contribute to urban biodiversity and aesthetics by supporting both aquatic and terrestrial ecosystems (Hassall & Anderson, 2014). However, sustaining their efficiency requires continuous management, particularly when biological processes, such as algal growth, disrupt their balance (Stahre, 2004).

Well-functioning SWP typically have diverse vegetation, which enhances ecosystem services like water purification and contributes to more resilient environments (Andersson et al. 2013). Algae and vegetation are the primary producers that can retain nutrients and pollutants through uptake (Monaghan et al. 2016). However, excessive algal growth can create operational challenges by deteriorating water quality, affecting aesthetics, and increasing maintenance costs (Stahre, 2004). The factors influencing algal proliferation are complex and include nutrient availability, water retention time, temperature, sunlight exposure, and biological interactions, among others (Stevenson, 1996). Assessing these triggers for algae bloom is essential for developing effective mitigation strategies.

In Uppsala Municipality, several SWP have been identified experiencing persistent algal issues, according to stakeholder consultations with professionals and researchers (see Appendix B; Expert Contact A, 2024; Expert Contact B, 2025). Investigating the causes for these blooms is important to find potential ways to reduce their occurrence. This study focuses on five SWP sites, four of which have exhibited excessive filamentous algae (FA) growth, where the fifth is a reference pond with no recorded excessive algae development. By analysing key water quality parameters, environmental conditions, technical aspects, and exploring potential management practices, this research aims to provide insights into the factors influencing algal proliferation and propose strategies to optimize pond maintenance.

1.1 Objectives

The primary objective of this study is to assess factors contributing to excessive development of filamentous algae (FA) in a few selected SWP in Uppsala municipality and explore potential mitigation measures. The findings can support more effective and sustainable maintenance strategies for stormwater made by municipalities in Sweden.

To be able to reach the above stated objective, this study seeks to answer the following research questions:

- What are the design criteria of the SWP, and how do they differentiate from the reference pond?
- How is the water quality of the SWP related to the presence of FA in some of them?
- Through observation and assessment of the SWP, can the triggers for excessive algal growth be identified?
- Which practices for managing excessive FA growth in SWP could be applicable for the studied sites?

1.2 Context and problem formulation

Uppsala municipality has set an ambitious goal to fully climate-adapt its urban environments by 2040 (Uppsala kommun, u.d.a). As the city continues to grow, with the development of new residential and service areas, the amount of impervious surfaces is increasing, placing additional pressure on existing stormwater systems (Uppsala kommun, u.d.b). A further challenge is that Uppsala is situated on a significant groundwater aquifer, which serves as the primary source of drinking water for the city's population. This is why the protection of this vital resource is prioritized in urban planning and water management (Uppsala Vatten, 2024).

One of the central challenges for Uppsala Municipality’s action on climate adaptation is preparing the built environment for extreme weather events, including both floods and droughts, which are expected to become more frequent and intense due to climate change (Uppsala kommun, u.d.a).

According to Uppsala Municipality's Comprehensive Plan (2016), the municipality is actively working to integrate blue-green infrastructure into the urban landscape. Stormwater is a major component of this strategy, with efforts focused on developing a sustainable and resilient infrastructure that can manage runoff while also providing additional ecosystem services, such as biodiversity support, recreational opportunities, and improved urban aesthetics (Uppsala kommun, 2016).

In line with the European Union's Water Framework Directive (WFD; 2000/60/EC), one of the stated goals in Uppsala Municipality's Comprehensive Plan is to achieve good ecological status for all surface and groundwater bodies within its jurisdiction by the year 2027 or year 2033 (Uppsala kommun, 2016). To support this objective, the municipality has adopted a Stormwater Management Plan as part of the Action plan for the municipality's Water Program, which aims to propose cost-effective measures to reduce the pollution of watercourses caused by the runoff among others. According to the plan, all new developments are required to implement sustainable stormwater management practices and design the systems capable of retaining 20 mm of rainfall over a 24-hour period, or 10 mm in areas situated near a recipient water body. Stormwater retention ponds are highlighted in the plan as effective measures for reducing levels of phosphorus (P), heavy metals, and certain organic pollutants in runoff (Stråe et al. 2019).

Uppsala Vatten is a company owned by Uppsala Municipality which provides a wide range of services, including drinking water production and distribution, wastewater management, waste collection and recycling, as well as biogas production (Uppsala Vatten, u.d.b). In accordance with the Public Water Services Act (SFS 2006:412), Uppsala Vatten is responsible for the management and treatment of runoff water within its designated operational areas. This includes not only the construction and maintenance of the stormwater sewer system but also other types of stormwater catchment and treatment facilities, such as wet SWP (Uppsala Vatten, u.d.a).

Currently, there are approximately 25 SWP in operation within the municipality, with plans to construct several more in connection with ongoing and future urban development (Uppsala Vatten, u.d.a; Norconsult Sverige AB, 2024b). Several of the existing ponds have been reported to experience problems with excessive macroalgae growth, which is often perceived as unaesthetic by the public (Expert contact B, 2025). According to the maintenance plans, algae should be mechanically removed when necessary; however, this operation can be associated with high costs (Uppsala Vatten, 2023b; Uppsala Vatten, u.d.). If multiple ponds require treatment each season, the total maintenance costs for the municipality could become substantial. This highlights the need to explore alternative solutions for managing algal growth in SWP more efficiently and cost-effectively.

2 Background

This section provides the necessary background to understand the problem of excessive algal growth in SWP and the context in which this issue arises. It is divided into two main parts. The first part, Theoretical framework, presents an overview of SWP as a common method for urban stormwater management and describes its core functions and features that can influence algal dynamics, followed by a short summary on ecology of filamentous macroalgae. The second part, Management practices, explores a range of approaches used to control algal blooms in stormwater systems, including biological, physical, and chemical strategies.

2.1 Theoretical framework

2.1.1 Stormwater ponds: function and characteristics

SWP have been implemented for close to 60 years in the USA, and they are nowadays the most common stormwater management structures globally, hundreds of them located in Sweden (Blecken, 2016).

These structures are engineered to capture a defined stormwater volume and release it gradually, attempting to reproduce natural hydrology and enhance stormwater quality through processes that occur in the natural environment (Yang & Lusk, 2018). Typically, SWP are designed to manage storm events with return periods of 10 to 100 years incorporating emergency overflows for larger events (Lusk et al. 2025). The efficiency of these structures in flood control depends on their maintenance.

Beyond flood control, SWP may provide ecosystem services and recreational and educational values (Blecken, 2016). Such multifunctionality require investment and care, because it may bring conflict amongst its amenities, for example if algal blooms arise, ponds may not be aesthetically pleasing for recreation (Andersson et al. 2013; Blecken, 2016).

In SWP, stormwater is naturally purified through sedimentation, which helps remove heavy metals, organic pollutants and P (Blecken, 2016; Andersson et al. 2013). Denitrification and nutrient uptake by plants are additional processes in water purification in SWP (Andersson et al. 2013). However, since these structures are mainly designed to manage stormwater, their efficiency in nutrient removal may be low, and in some cases, ponds may become sources of nutrients to downstream waters (Yang & Lusk, 2018).

Proper design of a SWP is important to avoid eutrophication and harmful algal blooms (HABs) (Liu et al. 2021). Relations as the macrophyte area to surface area, the shoreline development index (SDI) and the generation of waves and mixing by the wind are the most important factors to account for in reducing HABs (Liu et al. 2021). An irregular shape and an SDI value of 1.2 are recommended to help reducing the presence of HABs (Liu et al. 2021).

Hydraulic efficiency allows assessing the hydraulic design of a pond, making sure that the detention time remains consistent despite the inflows differ (Liu et al. 2021). It is also related to sediment removal, and the relationship of the pond area with the catchment area (Blecken, 2016). Efficient flushing occurs if the hydraulic efficiency is of 0.5 or more, reducing stagnant zones and short-circuiting (Blecken, 2016; Liu et al. 2021). Although hydraulic efficiency is not straightforward to determine, factors as the aspect ratio (length-to-width or L:W ratio), flow path length, residence time, vegetation, wind, and temperature significantly influence a pond's hydraulic performance and nutrient removal (Persson, 2000; Lusk et al. 2025; Liu et al. 2021).

In the design, a long and narrow pond performs better because a high aspect ratio gives high hydraulic efficiency (Andersson et al. 2013), as it promotes ideal uniform velocity profile, improves plug-flow conditions and reduces short-circuiting by making the flow path longer (Persson, 2000; Lusk et al. 2025). Although recommended ratios can vary and wind can influence flow patterns, an aspect ratio of at least 2:1 is generally considered cost-effective. A ratio of up to 4:1 is recommended to reduce the risk of short-circuiting and stagnant zones in ponds, where algal residues tend to accumulate (Liu et al. 2021; Persson, 2000; Lusk et al. 2025). Figure 1 shows the hydraulic efficiency parameter (λ) in relation to SWP shape, where the higher values indicate better hydraulic efficiency, as described by Blecken (2016).

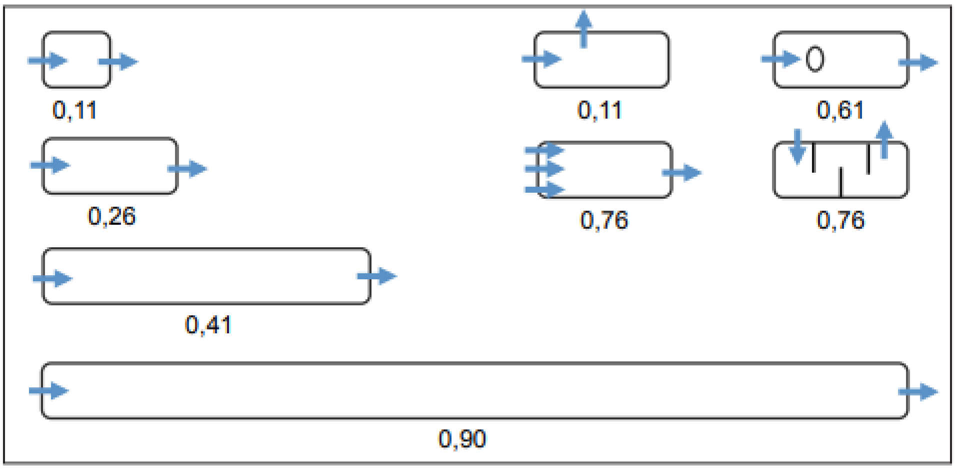

Figure 1: λ values based on the pond design (original: λ-värden baserade på dammutformning). Adapted from: Blecken (2016).

Alternatives such as multiple treatment cells, baffles, and managed vegetation, along with proper maintenance, can help mitigate short-circuiting if the recommended aspect ratio can't be met (Persson, 2000). Designs incorporating baffles may achieve similar hydraulic outcomes as long, linear ponds without needing extended physical dimensions (Persson, 2000). According to Persson (2000) integrating design elements like subsurface berms or inlet-facing islands can significantly improve hydraulic performance in ponds as an alternative to increase the aspect ratio.

The effect of wind on ponds, also called fetch, can negatively affect the macrophytes boosting the occurrence of HABs, or on the contrary, it could enhance mixing, reducing the possibility of presence of HABs (Liu et al. 2021). Low presence of macrophytes in ponds, long fetch distances and very regular shapes are common parameters where HABs have occurred (Liu et al. 2021). According to Liu et al. (2021), HABs are more likely to occur in two main conditions: low macrophytes cover and low SDI (less than 40% and 1.5 respectively) or low SDI and short fetch (less than 1.8 and 200 m respectively).

SWP are often provided by a pre-sedimentation unit, which deposits the coarser size of the sediments, in which metal concentration is lower close to the inlet, as they are bound to finer particles that settle near the outlets (Blecken, 2016). While deeper areas in the bottom of SWP favor the sedimentation process by reducing the flow velocity, shallow sections transversal to the flow direction help in the sedimentation processes, distribute the flow along the pond, and provide adequate conditions for vegetation (Andersson et al. 2013). The latter sets conditions for pollutant removal from water, as it allows different organisms to thrive and take part in water treatment processes (Andersson et al. 2013).

Regular inspection and removal of the accumulated sediments every few years must be granted (Blecken, 2016).

Crushed stones or plants can be used for the bottom and slopes of a pond (Andersson et al. 2013). Crushed rock functions adequately from the moment a pond is built, but plants help prevent erosion after some time, once they develop a vegetation mat, making maintenance easier. Ponds with hardened bottoms are a poor habitat for grazers, tending to have problems with algae more often (Andersson et al. 2013). When used on the slopes, plants discourage people from getting too close to the water and adequate vegetation can regenerate if any damage has been caused (Andersson et al. 2013). Densely grown vegetation may cause obstruction and water level rise with subsequent flooding and damage in the surrounding area (Andersson et al. 2013). Vegetation may also help to form channels where the water velocity is very high, affecting the sedimentation capacity of the pond (Andersson et al. 2013).

Nitrogen (N) removal is not very important in SWP, compared with wetlands, since stormwater carries lower concentrations (Andersson et al. 2013). N is not usually bound to particles, so it is not efficiently removed from water through sedimentation, but in biological nitrification-denitrification processes (Blecken, 2016). For example, dense vegetation creates anoxic conditions and supplies organic matter needed for the denitrification process, while shallow, vegetated areas promote biochemical processes that help remove dissolved pollutants (Blecken, 2016).

The pollutants, which are taken by plants, return to the water body when the plants die and decompose (Andersson et al. 2013). Harvesting and taking away the plants is a way to remove the pollutants permanently, but the amount of pollutant removal is lower in plant uptake compared to sedimentation (Andersson et al. 2013). Removing plants from the pond may also reduce its effectiveness in removing pollutants, as it can disturb settled particles and disrupt other ongoing purification processes (Andersson et al. 2013).

Andersson et al. (2013) distinguishes three types of plants in SWP. Emerged macrophytes (surface plants) which are rooted in the bottom and help fix sediments, evenly distribute water, remove and degrade surface oil, and support nutrient removal by providing surfaces and carbon source for bacteria in removal processes (Andersson et al. 2013). Submerged macrophytes (underwater plants) grow from the bottom but take the nutrients directly from the water. They provide oxygen and also shelter organisms involved in nutrient removal processes but are sensitive to deep water and to shading from algae and other plans, as they need sunlight (Andersson et al. 2013). Floating leaf plants can thrive in deeper ponds without competing for sunlight, while also providing habitat for organisms and bacteria. Additionally, they contribute to oil removal by capturing oil that enters the pond through runoff from urban areas, such as roads and parking lots (Andersson et al. 2013).

A well-developed vegetation structure in SWPs should comprise a combination of emergent and submerged macrophytes to ensure ecological functionality (Andersson et al. 2013). With an adequate density, emergent macrophytes help filter runoff and promote even water distribution. Submerged macrophytes contribute oxygen to deeper zones and further support filtration. Additionally, minimizing shading from trees is important to allow sufficient light for aquatic vegetation to thrive, if this is needed.

Seasonal changes affect SWP performance. Sunlight in summer boosts biological processes like N removal, whereas colder temperatures in winter reduce these rates (Andersson et al. 2013; Blecken, 2016). Ice cover can limit wind-induced mixing, leading to oxygen-depleted conditions. Moreover, heating by solar radiation, turbidity and temperature differences between inflowing stormwater and pond water can cause stratification, impacting sedimentation and oxygen levels (Blecken, 2016; McEnroe et al. 2013).

Large differences in temperature between incoming stormwater and pond water can create two separate flow currents. Colder inflow tends to sink and travel along the pond bottom, favoring resuspension of sediments, while warmer inflow stays near the surface, limiting sedimentation (Blecken, 2016). If inlets and outlets are shallow, this can reinforce thermal stratification, where the upper layer flows while the bottom becomes stagnant and oxygen-poor, disrupting key biological processes in the pond (Blecken, 2016).

According to Andersson et al. (2013), maintenance processes, as dredging and digging should take place after the summer or even in late autumn, when species of birds and amphibians have already gone through their reproduction season and may have left the ponds. When there's need to remove heavy mats of macroalgae and vegetation, due to esthetic or functional reasons, it is important to do it towards the end of summer (Andersson et al. 2013).

2.1.2 Water chemistry and interactions in stormwater ponds

The aquatic ecosystems in SWP, though similar to natural ones, experience differences due to urban influences (Lusk et al. 2025). For example, calcium carbonate from weathered concrete in urban ponds may affect the pH, impacting carbon and P cycling processes. Carbon and nutrient processing may also be affected by microplastics and heavy metals reaching the SWP.

Nutrient concentrations in SWP are important due to their role in promoting eutrophication and HABs (Yang & Lusk, 2018). Pollutant removal estimation in SWP focus on the changes in concentrations between the inflows and outflows, but cannot acknowledge the internal processes that occur, such as recycling of nutrients and organic matter (Lusk et al. 2025). In some cases, SWP perform as nutrient sources rather than sinks, due to such internal processes.

Nitrogen (N) in ponds exists in both organic and inorganic forms. Inorganic N is commonly found as ammonium (NH_4^+), nitrite (NO_2^-), and nitrate (NO_3^-), while P can be present as dissolved organic forms, orthophosphate (PO_4^{3-}), or as part of fine particles (Yang & Lusk, 2018). The differences in nutrient forms influence their processing, transformation and retention within the system.

2.1.2.1 Sources of nutrients in stormwater ponds

During storm events, surface runoff transports accumulated pollutants to SWP. The initial portion, known as the "first flush," often carries the highest concentration of pollutants, as it washes off most contaminants from surfaces before cleaner water follows (Lusk et al. 2025). Dissolved N tends to be easily flushed by light rainfall, whereas P tends to accumulate, especially over dry periods (Yang & Lusk, 2018). Nutrients also reach SWP through snowmelt, atmospheric deposition, erosion, fertilizers, irrigation runoff, animal waste, lawn clippings, and fallen leaves (Lusk et al. 2025; Frost et al. 2019). Preventive measures, such as removing leaves from streets and inlet grates, can help reduce P leaching once organic material enters the water (Yang & Lusk, 2018).

Nitrogen (N) and P removal in SWP can be contrasting processes, as the conditions that facilitate the removal of one nutrient may inadvertently enhance the retention or release of the other (Lusk et al. 2025). For example, conditions that remove N through denitrification can also release P from sediments, and aerating a pond to keep P buried may cause N to be released instead. These interactions show that N and P cycles are closely linked, so both elements need to be managed together to improve water quality effectively (Lusk et al. 2025).

Nutrients and carbon may settle or be absorbed into biomass, but they can be released back later into the water column through microbial mineralization or desorption, making SWP sources of dissolved nutrients (Lusk et al. 2025). Phosphorous (P), as a particulate-bound nutrient, tends to remain trapped in sediments unless redox conditions or pH shift significantly. Dissolved nutrient fractions as N are not effectively sedimented but undergo microbial transformation, such as mineralization and nitrification (Lusk et al. 2025).

Sediments, biomass and water are biogeochemical compartments for nutrients and carbon to move, being stored and released depending on oxygen availability, hydrology, and seasonal factors (Lusk et al. 2025). For example, denitrification in sediments can permanently remove N. Sediments in SWP are temporary storages for P, as it can be released back to the water under anoxic conditions, or in processes like mineralization, bioturbation, or resuspension (Lusk et al. 2025; Frost et al. 2019).

Algae, especially when forming diverse communities, as well as aquatic plants and heterotrophic microbes, can reduce nutrient bioavailability in ponds through assimilation, temporarily storing nutrients and limiting their export downstream (Lusk et al. 2025). When algae die and decompose, they release the previously nutrients back into the water and contribute to total suspended solids (TSS), potentially reducing the pond's efficiency in removing other particles. In contrast, algae and plants contribute organic matter to sediments, supporting microbial processes that enhance long-term nutrient removal. According to Lusk et al. (2025) promoting and maintaining healthy algal communities is essential for improving SWP water quality.

Macroinvertebrates also play a role by enhancing microbial breakdown of organic matter and increasing sediment oxygenation through bioturbation. (Lusk et al. 2025). Larger fauna, like fish influence nutrient dynamics both as sources (through excretion and movement) and as sinks (by incorporating nutrients into their biomass).

2.1.2.2 Algae, nutrient dynamics and water quality indicators

SWPs create favourable conditions for both plant and algal growth, where species compete for nutrients and light (Andersson et al. 2013). Planktonic algae play a dual role, serving as food for other organisms and acting as indicators of water quality, some species forming harmful cyanobacterial blooms (Minelgaite et al. 2020). Well-developed submerged macrophytes can limit microscopic algae by directly competing for nutrients in the water. In contrast, ponds dominated by FA present low species diversity due to unsuitable habitat for grazers, plants, and bacteria. Grazers and small animals help control algae by consuming zygotes before they start to grow after winter (Minelgaite et al. 2020). Minelgaite et al. (2020) made comparative study of SWPs in Denmark and Canada, finding that, despite environmental and geographical differences, phytoplankton communities in urban ponds closely resemble those in natural shallow lakes in both structure and diversity.

In eutrophic conditions, dense algal blooms can reduce water clarity and elevate pH levels due to high photosynthetic activity, which depletes dissolved carbon dioxide. Algae can use CO_2 and bicarbonate (HCO_3^-) at neutral to slightly alkaline pH, but cannot use carbonate (CO_3^{2-}), which dominates at higher pH. Consequently, extremely alkaline conditions may inhibit algal growth (Singh & Patidar, 2023).

Water conductivity reflects the concentration of dissolved ions and often correlates with algal density (Singh & Patidar, 2023). Minerals, such as iron, N, and P, released by microalgae may increase conductivity. Turbidity, an indicator of suspended solids in the water, can reduce light penetration and inhibit photosynthesis affecting algal growth, although it can also be caused by microalgae proliferation, and is often associated to chlorophyll-a concentrations (Ibid). Total nitrogen (TN) and total phosphorus (TP) are commonly used indicators of nutrient conditions, as they account for both dissolved and particulate nutrient forms, including those bound in sediments or taken up by organisms (Singh & Patidar, 2023).

Effective control of algal growth depends on identifying and limiting the nutrient that most restricts growth (Hartshorn et al. 2016). The TN:TP ratio is a useful indicator: values below 10 suggest N limitation, values above 17 indicate P limitation, and ratios between 10 and 17 imply co-limitation which means that changes in either nutrient alone are less likely to trigger algal blooms (Hartshorn et al. 2016; Florida LAKEWATCH, 2000). According to Florida Lakewatch (2000), lake trophic states can be classified based on TP and TN concentrations: oligotrophic lakes have TP<0.015 mg/L and TN<0.4 mg/L; mesotrophic, TP between 0.015–0.025 mg/L and TN between 0.4–0.6 mg/L; eutrophic, TP between 0.025–0.10 mg/L and TN between 0.6–1.5 mg/L; and hypereutrophic, TP>0.10 mg/L and TN>1.5.

Liu and Vyverman (2015) evaluated the nutrient removal efficiency and biomass production potential of FA under varying N:P ratios. *Cladophora sp.* showed effective P removal at low N:P ratios (approximately 5–15); *Pseudanabaena sp.* showed higher N removal under higher N:P conditions (ranging 7–20); *Klebsormidium sp.* was most efficient at intermediate ratios (7–10). These results highlight the potential of species-specific algal applications for targeted nutrient removal in water treatment systems (Liu & Vyverman, 2015).

2.1.2.3 Mixing conditions in stormwater ponds

Stormwater ponds (SWP) are often assumed to be well mixed due to their shallow depth, short residence time, and high sediment-to-water surface ratio (McEnroe et al. 2013; Frost et al. 2019). These features promote oxygenation of sediments and reduce P release, while also enhancing particle settling due to the short settling distance.

Ponds that are located in sheltered areas, experience low wind-mixing effects, and in eutrophic conditions, high phytoplankton densities reduce light penetration and vertical mixing, promoting stratification, especially during calm and sunny periods. Chemical stratification can occur in cold climates when melting snow and ice carry road salt into ponds, creating layers that resist mixing potentially causing oxygen depletion near the bottom. Stratification caused by salt has been found to be more prominent than thermal stratification in winter and early spring (McEnroe et al. 2013).

In their study of 45 SWP in Ontario, McEnroe et al. (2013) tested the assumption that these systems function as completely mixed reactors. Their findings showed that stratification does occur, likely driven by wind and heat effects. Many of the ponds were eutrophic, with high concentrations of phytoplankton near the surface. The authors concluded that urban ponds may only behave as completely mixed systems during rainfall and runoff events (McEnroe et al. 2013).

Pond depth should be below a limit, to avoid stratification in the pond, because it promotes the presence of anoxic conditions in the bottom releasing methane and P (Lusk et al. 2025). Though guidelines recommend depths between 1 and 3 m, to Liu et al. (2021) a mean of 2 meters is recommended to avoid resuspension of sediments and Ahmed et al. (2022) confirm that 2 m depth ponds avoid stratification and prevent eutrophication.

2.1.3 Ecology and dynamics of filamentous green algae in freshwater systems

Algae are a diverse group of unicellular and multicellular organisms that inhabit moist environments and perform photosynthesis. Their sizes range from microscopic phytoplankton to macroalgae that can grow several meters long (Andersson et al. 2013).

Algae play a fundamental role as primary producers in aquatic ecosystems, forming the base of the food web and contributing to biogeochemical cycling (Stevenson, 1996). Green algae (Chlorophyceae), in particular, serve as an essential food source for many grazers. Some genera, however, are less accessible due to their size and filamentous structure. In addition to being a food resource, green algae offer habitat and surface area for diatoms and small invertebrates, thereby enhancing biodiversity (Stevenson, 1996; Vadeboncoeur & Lowe, 2024).

Green algae reproduce both asexually and sexually. Asexual reproduction occurs via vegetative propagation, including cloning through zoospores (flagellated swimming spores) or akinetes (dormant, thick-walled cells). Sexual reproduction takes place through isogamy or oogamy. In isogamy, two morphologically similar gametes fuse, whereas oogamy involves the fertilization of a larger, non-motile egg cell (oogonium) by a smaller, motile sperm cell, typically while still attached to the parent organism (John, 2003). Notably, spores of some FA exhibit drought resistance, allowing for recolonization after unfavourable periods (Hillebrand, 1983).

Filamentous algae (FA), as part of the periphyton community, can be dependent on the availability of suitable substrata for their attachment and growth (Burkholder, 1996). Benthic FA can be distinguished based on the type of surface they colonize: epilithic algae attach to rocks and other hard substrates; epiphytic algae grow on macrophytes; epipelic algae inhabit soft sediments, among others; and unattached algae, such as *Mougeotia*, *Zygnema* and *Spirogyra*, float freely or settle loosely on the pond bottom. The types of attached algae can also contribute to the formation of the Metaphyton by the sloughing from the substrata.

The type and complexity of available substrate significantly influence the distribution, species composition, and ecological dynamics of algal communities (Stevenson, 1996). Algae that are growing on the sediments, or epipelon, can have access to the nutrient stored in pore water and therefore are more influenced by other environmental factors such as carbon availability, light and temperature (Ask, 2010; Enell & Löfgren, 1988). In contrast, mass of algae growing on rocks or wood (epilithon and epixylon) increase with the increased nutrient concentrations in the water column (Vadeboncoeur et al. 2001).

The proliferation of filamentous green algae, or Metaphyton, is particularly prominent in sheltered wetlands with stable water columns and high nutrient availability (Goldsborough & Robinson, 1996). In SWP, filamentous green algae can form dense surface mats since the conditions are often favourable (Andersson et al. 2013; Goldsborough & Robinson, 1996; Stevenson, 1996). In newly constructed ponds, site availability and lack of established macrophytes or competing algal communities, along with elevated nutrient levels further enhances the likelihood of rapid algal colonization and dominance (Andersson et al. 2013; Stevenson, 1996).

Cyanobacteria (Cyanophyceae) can also generate surface blooms, though these tend to be less dense due to differences in structural composition and buoyancy regulation (Oliver & Walsby, 1988). Algal mat development begins at the benthic zone, with rapid growth in early spring as temperatures rise following winter frost. During sunny periods, mats ascend due to gas bubble formation from photosynthetic activity, a process that slows but does not reverse under reduced solar radiation (Hillebrand, 1983). Over summer, the mats become denser before gradually submerging in autumn, though remnants may persist on the surface even through the first frost (Hillebrand, 1983).

Species composition within algal mats can shift seasonally. For example, in the Netherlands, *Spirogyra, Tribonema,* and *Microspora* have been observed as early as April, while *Spirogyra* ascends to the surface in May–June, *Mougeotia*, preceded by *Cladophora* and *Oedogonium*, becomes dominant in July–August. Notably, the ascent of *Cladophora* coincides with temperatures reaching 12–15°C in late May (Hillebrand, 1983). Additionally, different species exhibit specific ecological advantages; for instance, Zygnematacean algae are commonly found in acidic or acid-sensitive environments where nutrient availability is low (Gerrath, 2003; Stevenson, 1996). Further acidification can enhance periphyton complexity by negatively affecting larger grazers, thereby reducing grazing pressure (Planas et al. 1989).

Nutrient availability is the most critical factor influencing the growth of FA. Species such as *Cladophora* and *Stigeoclonium* commonly become abundant in hypereutrophic environments. FA typically require higher P concentrations than diatoms to achieve maximum biomass, with studies suggesting that 25–50 µg PO_4-P/L may be required due to limited nutrient flow within dense Metaphyton mats. However, in some cases, maximum growth has been reached at concentrations as low as 8 µg PO_4-P/L (Borchardt, 1996).

Water temperature is another key determinant of benthic algal dynamics, affecting growth rates, photosynthesis, respiration, and community composition. Diatoms (Bacillariophyceae) typically dominate at temperatures between 5 and 20°C, while green algae (Chlorophyceae) and yellow-green algae (Xanthophyceae) thrive in the range of 15–30°C. At temperatures exceeding 30°C, cyanobacteria (Cyanophyceae) become dominant due to their higher thermal tolerance (DeNicola, 1996). Light availability is another factor that influence green FA growth. Exposure to the high irradiance benefits the FA since their thread-like growth form allows them to physically shade out other types of algae which is a competitive advantage (Hill, 1996).

Grazers and algae interact in complex ways that influence FA dynamics in SWP. The presence of small- to medium-sized grazers can lead to increased algal biomass due to selective feeding on attached epiphytes rather than directly on large-celled algae such as *Cladophora* (Steinman, 1996). Nonetheless, certain species like Trichoptera larvae can effectively regulate algal growth through grazing, although they are sensitive to pollution and are often used as indicators of good environmental quality.

Other invertebrates, such as gastropods (e.g., slugs and snails), also contribute to FA control. Larger grazers, including small cyprinid fish (e.g., minnows), crayfish, and tadpoles, are generally the most effective at reducing FA biomass. However, grazing pressure is primarily effective on early-stage periphyton; once FA mats become dense and well-established, they are considerably more resistant to grazing (France et al. 1991). Moreover, the effectiveness of grazing is also dependent on the timing, other resource availability, grazer preferences and their density (Steinman, 1996).

FA mats not only impact ecosystem structure but also influence water temperature stratification and turbulence reduction. Interestingly, there is strong evidence that FA can be allelopathic and may inhibit the growth of the phytoplankton in shallow lakes at non-limited nutrient concentrations (Trochine et al. 2010). During periods of high temperatures, the upper mat layers may transition to a yellow-green colour due to algal senescence and decomposition (Hillebrand, 1983). Environmental conditions most conducive to algal proliferation include low N:P ratios, higher calcium concentrations, alkaline pH, strong irradiance, and eutrophic conditions (Stevenson, 1996). Historically, in some regions of the Netherlands, algal mats were even harvested for use as natural fertilizers (Hillebrand, 1983).

2.2 Management practices

Several methods intend to contribute to algae growth control in different manners. Biological methods deal directly with the ecosystem, while chemical and physical methods intervene indirectly in the ecosystem and directly into nutrient removal from SWP. Such varied methods have been used or are under study to contribute to avoiding algal blooms in SWP, as shown in the following sections.

2.2.1 Biological methods

Biological methods intend to regulate algal growth by introducing organisms like macrophytes and grazers that compete with algae, or natural substances to inhibit their growth mechanisms.

2.2.1.1 Barley straw

Barley straw has been widely used as a method to control nuisance algal blooms and excessive algal growth in water bodies. When added to water, the slow aerobic decomposition of barley straw has been shown to inhibit algal growth, often resulting in improved water clarity in small aquatic systems (Ridge et al. 1999). Without any specific pre-treatment, the straw typically becomes "active" after approximately three months and can remain effective for up to six months when applied in doses ranging from 3 to 50 g per cubic meter. The primary mechanism of inhibition is believed to be linked to the solubilization and subsequent oxidation of lignin (Ridge & Pillinger, 1996). However, other compounds such as tannins and oxidized polyphenolics, found in the litter of deciduous trees among others, have also demonstrated inhibitory effects on algal growth (Ridge et al. 1999; Ridge & Pillinger, 1996).

Ball et al. (2001) demonstrated in a laboratory experiment that the addition of barley straw extract, particularly with a high lignin content, to lake water containing *Microcystis* sp. (cyanobacteria) and *Scenedesmus* sp. (green algae), effectively inhibited their growth. The use of barley straw extract offers an advantage over whole barley straw bales, as it does not contribute additional nutrient loads during decomposition (Ball et al. 2001).

A study by Welch et al. (1990) showed that the use of barley straw in a eutrophic, disused canal had a long-term inhibitory effect on the filamentous green alga *Cladophora glomerata*, while showing no significant impact on phytoplankton communities. Furthermore, the addition of barley straw did not result in a significant reduction in nutrient concentrations downstream of the treatment site. The authors suggested that the observed inhibition might be linked to an increased abundance of invertebrates associated with the straw, although they also noted that grazing was unlikely to account for the reduction in *Cladophora* growth due to the relatively large size of its cells (Welch et al. 1990).

Another study conducted by Caffrey and Monahan (1999) demonstrated the effectiveness of barley straw in reducing the growth of *Cladophora glomerata* in a section of an open canal, while also supporting the establishment of a macrophyte community.

A study by Gibson et al. (1990) investigated the inhibitory properties of barley straw on several filamentous and unicellular green algae under laboratory conditions. The results demonstrated that the presence of freshly decomposing barley straw effectively inhibited the growth of various FA, whereas autoclaved barley straw had no such effect. Additionally, although water discoloration occurred during the decomposition process, it was determined that this had no significant shading effect on algal growth (Gibson et al. 1990).

A later study conducted by Fervier et al. (2019) tested three different strategies, including barley straw treatment, to reduce nuisance algal growth in a eutrophic environment. The experiment was carried out in mesocosms indoors. Among the strategies, none has proved to be the very effective in decreasing FA biomass; nutrient reduction had some reduction effect. While barley straw treatment did not significantly reduce FA, it had a positive effect on the growth of macrophytes and diatoms. The authors suggest that the barley straw may still exert an indirect inhibitory effect on FA by promoting macrophyte growth, which could eventually dominate as the primary producers. Additionally, the study indicates that barley straw may be effective in inhibiting the growth of cyanobacteria, which are known to produce harmful toxins (Fervier et al. 2019).

In Sweden, barley straw is being used to control the nuisance algae growth both in ornamental ponds and SWP (Permbro, 2021; Ystads Allehanda, 2013). According to the water and wastewater design engineer at Täby municipality, the placement of barley straw bale in the inlet of the stormwater can reduce algae but there was no specific evaluation of the effectiveness of the method in the ponds where this method was applied (Expert contact D, 2025).

The advantages of using barley straw as an inhibitory method for controlling nuisance algae include its low cost and the lack of significant negative effects on invertebrates and other aquatic organisms (Everall & Lees, 1996). However, the method provides only temporary effectiveness and does not address the underlying causes of excessive algal growth, which are typically linked to elevated nutrient concentrations (Ridge et al. 1999).

2.2.1.2 Use of macrophytes

According to Liu et al. (2021), the presence of macrophytes limits the growth of cyanobacteria and also competes with algae for nutrients. They provide shading that limits the light reaching the pond, as well as shelter for grazers on algae.

These macrophytes may also produce allelopathic substances which may suppress algae growth.

According to Andersson et al. (2013), studies on 18 small wetlands for N removal showed that the ones with above-water vegetation performed better than those with underwater vegetation during their first years, but this difference diminished in time. About P, they state that no specific studies have been made in Sweden, but vegetation has an important role against phytoplankton blooms. Since it is not possible to define a specific kind of vegetation that boosts nutrient removal in ponds, it is always better to have a variety of species than a dominant one (Andersson et al. 2013).

The vegetation variety in SWP should be formed by species of sedges and wetland-like plants, and species that adapt rapidly to new environments i.e. cottongrass (ullsläktet), three-lobe beggarticks (brunskära) and great willowherb (rosendunört) (Andersson et al. 2013).

2.2.1.3 Biomanipulation

Biomanipulation is a biological control method that can help to restore or maintain ecological balance in aquatic ecosystems, including SWP. One strategy involves the deliberate introduction of grazers, such as zooplankton, to reduce excessive algal growth by increasing grazing pressure on phytoplankton (Dodds & Gudder, 1992; Fervier et al. 2019; Hillebrand, 1983). However, the effectiveness of this approach may be compromised in ponds where fish are present, as many fish species predate on zooplankton, thereby reducing their grazing efficiency (Hansson et al. 2004). The outcome depends largely on the species composition and presence of fish in the specific pond. Additionally, other aquatic organisms, such as amphibians, bigger crustaceans, and also birds, may also feed on invertebrate grazers, influencing the overall success of biomanipulation strategies (Nyström et al. 2001). Nevertheless, herbivorous fish and other large grazers can also be effective in controlling FA biomass (France et al. 1991).

2.2.2 Physical methods

The physical methods include direct mechanical interventions in the pond, as well as interventions in relevant environmental variables involved in algal development.

2.2.2.1 Manual removal

The simplest method for controlling algal growth is manual removal. This approach is currently employed by Uppsala Vatten as the primary maintenance strategy for managing excessive algae in SWP. While effective in the short term, manual removal is not only labour-intensive and costly, but it also addresses only the symptoms of the problem rather than preventing algal growth at its source (Uppsala Vatten, u.d.).

2.2.2.2 Limiting solar irradiation

Limiting solar irradiation could be an effective method to control algal growth in SWP. This can be achieved through natural shading, by planting trees and aquatic macrophytes or by installing artificial shading screens. Natural shading is generally preferred, as it not only reduces light availability for algae but also enhances ecological value by promoting biodiversity. Stahre (2004) recommends planting trees around SWP where possible to reduce sunlight exposure.

According to Clawson (2016) adding dyes to the water is a short-term solution with immediate effect, to reduce algal growth. These dyes are used in small ponds and recreational sites, adding blue or black colour to the water, to address filamentous and blue-green algae growth (Clawson, 2016). Dyes reduce the penetration of UV rays into the water with its shading effect, reducing photosynthesis and reducing the phytoplankton production (Clawson, 2016; Lusk, 2023). While Clawson (2016) mentions that dyes are not hurting aquatic animals, but some effects to underwater plants can be produced, Lusk (2023) mentions that pond dyes may affect the base of the food chain affecting the whole ecosystem.

The use of pond dyes can become an adequate tool, if it is used carefully to interfere and manage algae bloom cycles (Lusk, 2023). For example, dying a pond during the late winter and early spring months where FA start to wake may postpone the moment where algae bloom. Under the effect of pond dyes, plankton dies and settles, clarifying the water (Lusk, 2023).

2.2.2.3 Aeration and mixing

Aeration is another strategy to manage nuisance algae, particularly in smaller ponds. A widely used method for surface aeration involves the installation of fountains (Stahre, 2004). While effective at oxygenating surface waters, fountains may be insufficient for circulating oxygen throughout the entire water column, particularly during warmer periods when thermal stratification occurs. In such cases, the installation of air diffusers is recommended. These devices help maintain aerobic conditions in deeper parts of the pond, typically those exceeding 2.5 meters in depth, by preventing the release of P and other pollutants from anoxic sediments and by promoting microbial activity that competes with algae for available nutrients (US EPA, 2009).

Stahre (2004) also emphasizes the importance of pond design in minimizing algal blooms. Inlet zones should ideally include biological filters, such as shallow, wetland-like areas where macrophytes (e.g., reeds) can uptake nutrients and provide surfaces for microbial communities. Additionally, the use of a pump system is advised to maintain water circulation and prevent stagnation. A nearby water post is also recommended, enabling water to be added during dry periods when water levels drop (Stahre, 2004).

Aeration and mixing have been employed by Malmö Municipality as a strategy to control algal growth in the open stormwater system of the Western Harbour B001 area, one of Sweden's first climate-smart neighbourhoods and a prominent example of sustainable urban development (Al-Mehdawi & Jamalaldin, 2014; Malmö stad, 2015). In this system, mixing is achieved using vortex generators and a pumping system, which help to prevent water stagnation and replicate natural aeration processes. While this approach has proven effective in mitigating algal growth, it also presents several challenges, including high operational costs, the need for regular manual maintenance, and issues related to the upkeep of the pumping equipment (Al-Mehdawi & Jamalaldin, 2014).

Hansen et al. (1997) made a study on the effects of resuspension of P in Lake Okeechobee, which is a nutrient-rich lake in Florida. Authors explored two hypotheses for this: either the sediment resuspension brings up a source of P, or the sediments have such adsorption capacity that when resuspended can take away P from the water column. Their results show that strong mixing cause by the wind in some seasons, generated oxic conditions in the resuspended sediments, removing P from water, thus reducing algal growth potential. During less windy seasons, the calmer regime of the lake allowed anaerobic conditions in the sediments, favouring P release into the water and promoting algal growth (Hansen et al. 1997).

2.2.2.4 Use of filters

Erickson et al. (2018) made a study about the use of an iron-enhanced sand filter (IESF) for retention of P from stormwater in a pond in Minnesota. One practice tested was a filter which was installed along the perimeter of the pond. The results showed that in half of the events, a negative removal of PO_4^{3-} was observed, likely due to the accumulation of this compound in the filter. However, the filter's performance appeared to improve following maintenance. Erickson et al. (2018) also tested a traditional filter, which required maintenance to remove vegetation and iron ochre, as a waste product of the filter. The traditional filter showed retention of phosphate in all the events that occurred in this case study, thus becoming apparently the best performing filter of the two tested. It is important to note that the IESF, also known as Minnesota filters, are not intended to be flooded, on the contrary, these require to be properly dried out between rainfall events (Minnesota Stormwater Manual, 2020).

2.2.2.5 Ultrasound treatment

Other methods for algal control include ultrasonification, or ultrasound treatment, which may be suitable for smaller water bodies. Several laboratory and field studies, mainly focused on cyanobacteria, have shown varying degrees of success. Most findings indicate that ultrasound at specific frequencies can reduce algal cell numbers (Park et al. 2017). Purcell et al. (2013) found that filamentous cyanobacteria with larger surface areas are particularly susceptible to ultrasound treatment.

2.2.3 Chemical methods

The chemical control methods include promotion of changes in water chemistry that could hinder algal growth in the short term but also have more important impacts on the ecosystem.

2.2.3.1 Use of algaecides

Greenfield et al. (2014) made a study on the efficacy of two copper-based algaecides and one sodium percarbonate-based algaecide, to control cyanobacterial blooms which are the main cause of HABs in ponds. Their main finding was that the copper-based algaecides were more effective in reducing the amount of cyanobacteria, but none of the three algaecides lead to a decrease in overall microcystin (toxin) concentrations. This shows that while the algaecides destroyed the cells, toxins were still released in the water making the risk to public health persist (Greenfield et al. 2014).

The use of algaecides to control HABs needs to be assessed considering its advantages and disadvantages. Algaecides can be cost-efficient and practical but harmful for other aquatic organisms, while nutrient reduction in water is a more likely strategy to control algal blooms in the long term (Greenfield et al. 2014; Singh & Patidar, 2023).

2.2.3.2 Advanced oxidation processes

Advanced oxidation processes (AOPs), such as ozonation, photocatalysis, Fenton reactions, hydrogen peroxide, electrochemical oxidation and others, appear to be promising manners to control toxic algal blooms by inactivating algal cells and degrading toxins with minimal secondary pollution (Gao et al. 2025; Yu et al. 2023).

However, in their studies both Yu et al. (2023) and Gao et al. (2025) emphasize that further research is needed before implementing these methods in real conditions. The variable factors involved and the potential formation of harmful byproducts from algal toxin degradation raise concerns about ecological impacts and treatment reliability outside controlled environments.

2.2.4 Integrated approaches

This section is reviewing integrated approaches that includes hybrid strategies that may combine physical infrastructure, chemical interactions and ecological processes. Additionally, some other methods are discussed.

2.2.4.1 Use of sediments

In ponds where the ecosystem is poorly developed, i.e. due to hardened bottom and slopes, transferring sediments from a well-established donor pond can enhance ecological conditions (Andersson et al. 2013). Such donor pond should have thriving benthic flora and fauna, to enrich the biological community and create more suitable conditions for submerged vegetation (Andersson et al. 2013). According to Andersson et al. (2013), this sediment transfer process requires permissions to extract the sediments and hold careful handling during installation. Additionally, deepening the ponds to at least 1.2 meters can improve sedimentation in ponds (Andersson et al. 2013).

Phosphorous (P) removal mechanisms are mainly plant uptake and adsorption in sediments (Yang & Lusk, 2018). Younger ponds with fresher sediments tend to show better P retention, likely due to their unsaturated state. Over time, sediment saturation can reduce effectiveness, leading to internal P loading. The problem of internal loading of P in ponds can be addressed physically, by dredging the sediments, or chemically, increasing the sorption capacity of sediments adding iron, alum or calcium, to improve the fixation of P (Søndergaard et al. 2003).

2.2.4.2 Allellopathy

Shallow lakes can shift between conditions of turbid water, often related to the presence of phytoplankton, to clear water, when submerged plants are part of the system. Filamentous algae (FA) may be a control mechanism for phytoplankton, which could cause turbidity in water as lakes and ponds get warmer (Trochine et al. 2010). However, as temperature rises, the excessive presence of either phytoplankton or FA forecast ecological degradation in waterbodies (Trochine et al. 2010).

In their study, Trochine et al. (2010) concluded that FA (*Cladophora* sp. and *Spirogyra* sp.) hinder phytoplankton growth, very likely due to allelochemicals release, which may be related to higher temperatures. They also confirmed that the presence of FA may contribute to promote clear water in shallow lakes, in nutrient rich water, as they negatively affect the production of phytoplankton. They also showed that clear water and FA growth may occur under nutrient rich concentrations and high temperatures.

2.2.4.3 Attached growth systems

Though reducing the inputs of nutrients towards waterbodies may be helpful to enhance water quality, some nutrient sources are difficult to spot and control, and internal processes in waterbodies (i.e. nutrients in sediments) also affect negatively water quality (Singh & Patidar, 2023).

The idea of growing algae as biofilms both for water treatment and algae harvesting has been studied in recent years (Singh & Patidar, 2023). For this purpose, periphyton and filamentous can be considered for water treatment, and biomass generation which can be used for purposes like biofuel production. In an experimental study to treat nutrient-rich water using microalgae attached to mortar surfaces, Singh and Patidar (2023) showed that the use of the attached growth system, improved water quality and produced valuable algal biomass, which was easy to recover from the carrying surface. The use of an attached growth system has a potential to control the internal presence of nutrients in water, as their inflow is not always possible to regulate (Singh & Patidar, 2023).

2.2.4.4 Floating treatment wetlands (FTW)

These installations allow plants to grow attached to a foam surface, where the plant roots form mats which hang in the water and intake nutrients, promote sediment filtering, and adequate conditions for microorganisms to interact with nutrients and organic matter (Hartshorn et al. 2016; McCoy et al. 2024). Being floating structures, they handle depth changes well and can be adapted in size and shape as needed (McCoy et al. 2024). Andersson et al. (2013) suggest that conditions for biodiversity, such as birds, can be boosted using nesting islands. For permanent removal of nutrients, it would be necessary to remove the plants instead of only trimming them, during maintenance process (Yang & Lusk, 2018). The use of FTW downstream may be recommended as a polishing step to achieve significant P reduction in the water. Removal of close to 50% of N and P has been reported with the use of these elements.

Hartshorn et al. (2016) found a stronger correlation between TP and chlorophyll-a, compared to TN and chlorophyll-a, in a study on three SWP in Orlando (Florida), about the relation between nutrients, microcystin and chlorophyll-a when installing FTW. The found correlation showed that P availability boosts algal growth. With regard to nutrient concentration and microcystin, correlations were negative. However, the correlations between nutrients, microcystin and chlorophyll-a may vary, as they can be influenced by site-specific conditions (Hartshorn et al. 2016).

In Densmore pond in Nebraska (USA), McCoy et al. (2024) performed laboratory and field research on the effectiveness of FTWs on NO_3^- removal efficiency, with unaerated and aerated conditions. The results showed that algae reduction does not occur abruptly, so during the initial years of treatment some algae mats (*Cladophora*) would be present in the pond, but in progressively less amounts. Not only FTWs can reduce NO_3^- concentrations in SWP, but promoting aerated conditions in them may become an effective strategy to reduce nutrient pollution in ponds (McCoy et al. 2024).

2.2.4.5 Community engagement and information sharing

Educational outreach and clear communication with stakeholders can play a significant role in reducing nutrient inputs and algae proliferation in SWP. Monaghan et al. (2016) explored the dual function of residential SWP, emphasizing their role in both stormwater management and neighbourhood aesthetics in a planned community in Florida. They showed that while many residents understand the technical function of ponds, such as flood control and pollutant capture, their engagement is often influenced by maintenance concerns and aesthetic preferences (Monaghan et al. 2016).

Encouraging best management practices such as limiting nutrient inputs, maintaining vegetated shorelines, and incorporating non-invasive aquatic plants can improve both ecological performance and resident satisfaction. This requires more than awareness alone, thus targeted communication strategies, tailored to residents' values and concerns, can increase the adoption of such practices (Monaghan et al. 2016).

3 Materials and methods

To assess the possible causes and potential mitigation strategies for excessive algal growth in selected urban SWP, the methodology combined field observations, laboratory analysis, literature review and site-specific assessments for the SWP. The fieldwork consisted of inspections around the ponds' locations and water and algae sampling. Laboratory analysis were conducted to determine water quality parameters and identify the algae present. Literature review involved studying official public reports and detailed information provided by Uppsala Vatten, as well as research in other published sources. Unpublished sources such as stakeholder consultation with experts were also used as part of the data gathering for the purposes of this study. These various methodological components are described in detail in the following sections.

Once the data collection, laboratory analyses and literature review were completed, the information was analyzed and discussed. The results include a physical comparison of the ponds, water chemistry trends over the study period, and identification of algal species in each pond. These findings, along with the additional information, were then incorporated into a detailed assessment of the ponds. A schematic summary of the methodology and workflow is shown in Figure 2.

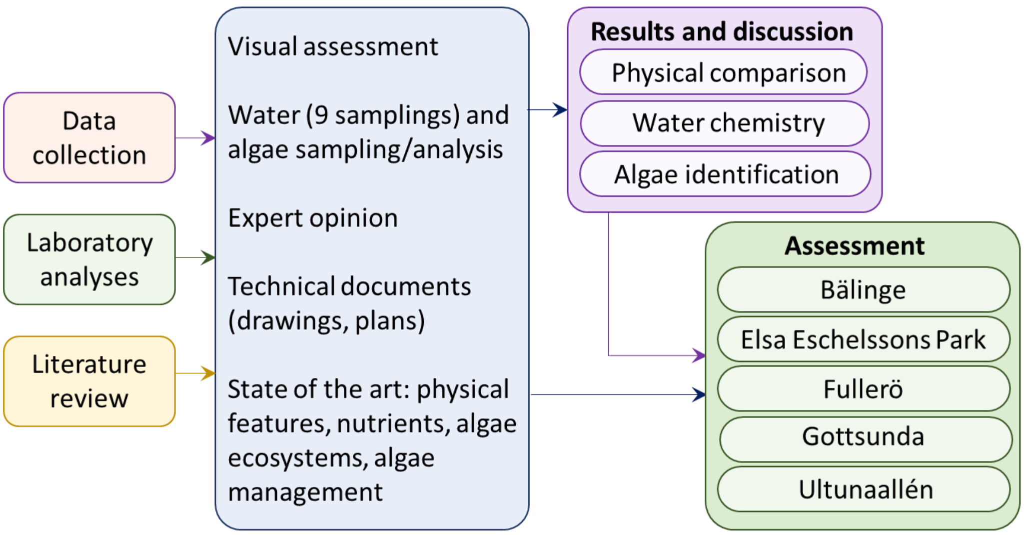

Figure 2: Summary diagram of projects' workflow and methodology.

3.1 Selected sites and their geographical location

The five ponds included in this study are located in different areas of Uppsala and its surroundings, as shown in Figure 3. Gottsunda Dagvattenpark is situated in southern Uppsala, about 5 km from the city centre, within the Hågadalen-Nåsten nature reserve. Another studied pond is located at Ultunaallén on the SLU university campus grounds.

The SWP along Fjädermolnsvägen are found in Fullerö, approximately 9 km northeast of central Uppsala. Elsa Eschelsson's Park, located in Rosendal, is an urban stormwater feature within a newly developed district relatively close to the city centre.

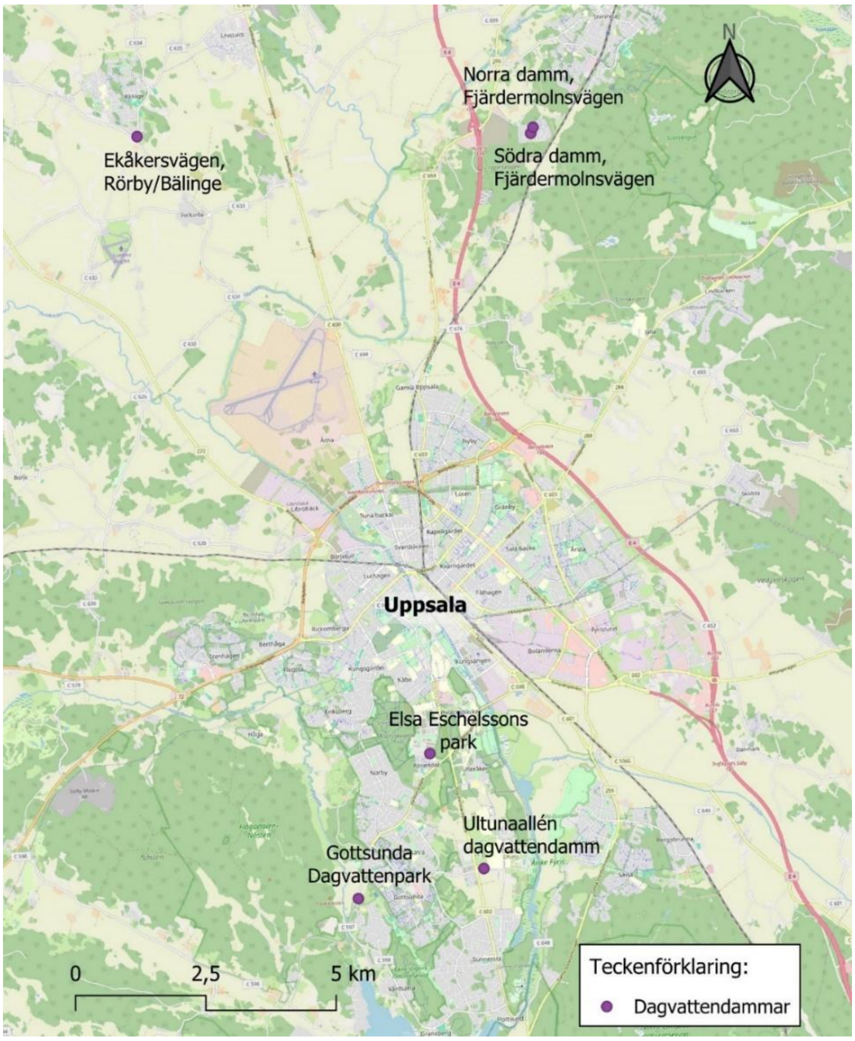

Figure 3: The locations of the SWP that are included in the study © OpenStreetMap

The SWP at Ekåkersvägen in Rörby/Bälinge is situated approximately 12 km northeast of Uppsala city centre. Further detail on the configuration of the SWP can be found in the extractions of the floor plans and cross sections from the construction drawings in Appendix F.

3.1.1 Ekåkersvägen, Rörby/Bälinge (reference pond)

The SWP in Rörby/Bälinge was constructed in 2016 for stormwater retention. It is located approximately 12 km northeast of Uppsala city center, in Bälinge. The total catchment area of the pond is estimated at 8.2 hectares, while the effective contributing area is 1.5 hectares.

Figure 4: Pond at Ekåkersvägen in Rörby/Bälinge captured from the south on October 8, 2024 (photo by Margarita Judina).

The catchment consists of single-family villas, green spaces, pedestrian and bicycle paths, and roads (Uppsala Vatten, 2023a). The pond is surrounded by a security fence, as shown in Figure 4, but it can be accessed if needed through two unlocked gates.

The pond bottom is constructed with geotextile and covered with crushed stone. The slopes have an incline of 1:3 in the deeper part and 1:5 above the average water level. The design prevents direct infiltration into the groundwater, though some infiltration may occur during precipitation events exceeding the pond's capacity. In such cases, excess water will also bypass into a roadside ditch. The maximum outflow from the pond is limited to 17 l/s (Uppsala Vatten, 2023a).

The water surface area is estimated to be 200 m^2 at normal water levels and 500 m^2 at high water levels. The depth of the pond at its permanent water level is approximately 1.2 meters. The constant water volume is 155 m^3, while the regulation volume is 310 m^3. The estimated turnover time for an average annual rainfall event (7.3 mm over 6–7 hours) is 8.5 hours. The retention time for a 10-year rainfall event lasting 10 minutes is approximately 6.5 hours (Uppsala Vatten, 2023a).

The pond has one inlet from the east and one outlet in the northwest, which discharges into a stream connected to Åloppebäcken and Jumskilsån. These waterways eventually flow into Fyrisån and ultimately reach Lake Mälaren (Uppsala Vatten, 2023a).

3.1.2 Gottsunda Dagvattenpark

Gottsunda Dagvattenpark is a SWP that was constructed in 2020, according to Norconsult Sverige AB (2024a), and was put into operation 2021, with the primary purpose of stormwater treatment but also as a multifunctional recreational space for residents of the nearby residential areas (Stenström et al. 2019).

The pond's total catchment area is 101 ha, but its design was based on the reduced catchment area (the area of impervious or semi-impervious surfaces that contributes to stormwater runoff), estimated at approximately 30 ha, accounting for future development. The catchment area includes a mix of land uses, such as single-family homes, apartment buildings, parking lots, streets, allotments, forests, and meadows. The treated stormwater is discharged into a ditch beneath Vårdsätravägen, which then flows into Hågaån before ultimately reaching Lake Mälaren (Stenström et al. 2019).

The design of the pond includes three pre-sedimentation ponds, the main pond, seen in Figure 5, which has the average water surface area of about 4 500 m^2, volume of 5 200 m^3 and average depth of 1,15 meter, and an open ditch paved with stones that connects one of the pre-sedimentation ponds with the main pond. The slopes of the eastern side of the pond are gentle, with an incline of 1:8, allowing for water level fluctuations over a shallow area. In contrast, the slopes on the western side are steeper, varying between 1:3 to 1:5 incline (Stenström et al. 2019).

Figure 5: Gottsunda Stormwater Park captured from the south on October 8, 2024 (photo by Margarita Judina).

The bottom of the pond consists of a dense clay layer that was originally present on the site. According to the system description document by Stenström et al. (2019), some water infiltration into the clay material is expected, and coarser materials may have been placed along the shores to create diverse environments.

During the period between May and November 2022, the consulting company WRS, in collaboration with SLU, Uppsala Municipality, and Fyrisåns Vattenvårdsförbund, conducted a pilot study in which Gottsunda Dagvattenpark was one of the investigated ponds. The study aimed to enhance knowledge about the ability of SWP to remove pollutants and to improve the understanding of stormwater composition and the relationships between various chemical and physical parameters (Näslund et al. 2023).

Next year, under the period between May and November 2023, Gottsunda Stormwater Park was monitored by Norconsult Sverige AB at the request of

Uppsala Municipality within the framework of the Life IP Rich Waters project to evaluate the treatment efficiency of the pond. Automatic water sampling was conducted at the inlets and outlet, and chemical analysis of the water samples included turbidity, TSS, TP, total Cl, metals, and organic pollutants. No sediment sampling was carried out during this period (Norconsult Sverige AB, 2024a).

Another study, that was built on data gathered by Norconsult Sverige AB (2024a), was a master's thesis by Svenda (2024). The goal of this study was to evaluate the pollutant removal efficiency of Gottsunda Dagvattenpark. The study investigated whether continuous turbidity sensor measurements and water flow data could effectively assess pollutant transport and treatment, focusing on suspended solids, P, and metals (Svenda, 2024). Another master's thesis, conducted by Ejderby (2023) a year earlier, examined Gottsunda Dagvattenpark from a different perspective by mapping and evaluating its provided ecosystem services.

During the summer of 2024, researchers from the Swedish University of Agricultural Sciences (SLU) conducted surface water and greenhouse gas sampling. Water sampling, followed by accredited chemical analyses, was carried out within the framework of the ongoing Puddlejump project (Expert contact E, 2025). As part of this project, citizen science data was also collected, including public observations such as photos, Secchi depth measurements, water levels, and comments on perceived recreational value (SLU, 2024). The photos and laboratory analysis data were kindly provided for this study by Expert contact E (2025).

3.1.3 Fjärdermolnsvägen, Fullerö

Two interconnected SWP, located on both sides of Fjädermolnsvägen in Fullerö were constructed in 2016 to retain and manage stormwater runoff. The total catchment area is 22.3 hectares, with an effective contributing area of 7.3 hectares. The area includes single-family villas, apartment buildings, a kindergarten, a playground, paved pedestrian pathways, roads, and green spaces (Uppsala Vatten, 2023b).

Figure 6: Southern Pond at Fjärdermolnsvägen, Fullerö captured from the south on October 8, 2024 (photo by Margarita Judina).

The southern pond, shown in Figure 6, receives water through a stone-paved ditch that runs along the playground and green area in the south, as well as from an inlet on the northwest side. Its outlet directs water to the northern pond, which has two additional inlets: one from a stone-paved ditch in the northeast and another from an inlet pipe in the east. Water from the northern pond is discharged into the stormwater pipe system, which eventually leads to another pond before flowing through a ditch into Fyrisån and ultimately reaching Lake Mälaren (Uppsala Vatten, 2023b).

The pond bottoms are filled with crushed stone, with geotextile underneath to prevent infiltration into the ground. The slopes have a 1:5 incline in the upper part, while beneath the water surface, the incline steepens to 1:3. The normal water depth in both ponds is around 1.3 meters, with a maximum water depth of 2.1 meters. The permanent water volume is 536 m^3 for the southern pond and 617 m^3 for the northern pond, while the regulation volumes are 720 m^3 and 864 m^3, respectively. The low water surface area is 600 m^2 for the southern pond and 700 m^2 for the northern pond, both of which double in size during high water levels (Uppsala Vatten, 2023b).

The ponds do not have a bypass system and cannot be fully drained for maintenance. The outflow from the northern pond is restricted to 90 l/s to control discharge rates. The estimated retention time for both ponds is 13 hours during an average annual rainfall of 7.3 mm (Uppsala Vatten, 2023b).

3.1.4 Elsa Eschelssons Park

The pond in Elsa Eschelssons Park was put into operation in 2022 as a multifunctional space that integrates stormwater management with recreational activities such as a skate park, basketball court, and other activity areas, as shown in Figure 7. According to the design, a permanent water surface is located in the eastern part of the park, while during heavy rain events, the concrete basin on the western side, usually intended to be used as an activity space, is designed to be temporarily flooded. The total catchment area of the pond is 6.6 ha, while the effective contributing area is estimated to be approximately 4 ha (Bjerking, 2020).

The land use in the catchment area is urban and includes apartment buildings, a kindergarten, school sports facility, parking spaces, streets, and green areas (Uppsala kommun, 2024). A distinctive feature of the area is its stormwater collection system, which includes numerous rain beds integrated into the street environment. These rain beds, measuring between 1.5 and 3 meters in width, are constructed as reservoirs filled with crushed stone at the bottom and plant substrate on top. They are designed to retain water and reduce pollutant loads in stormwater. Several rain beds in the catchment area are connected to the pond in Elsa Eschelssons park (Melin et al. u.d). The area is still partially under construction.

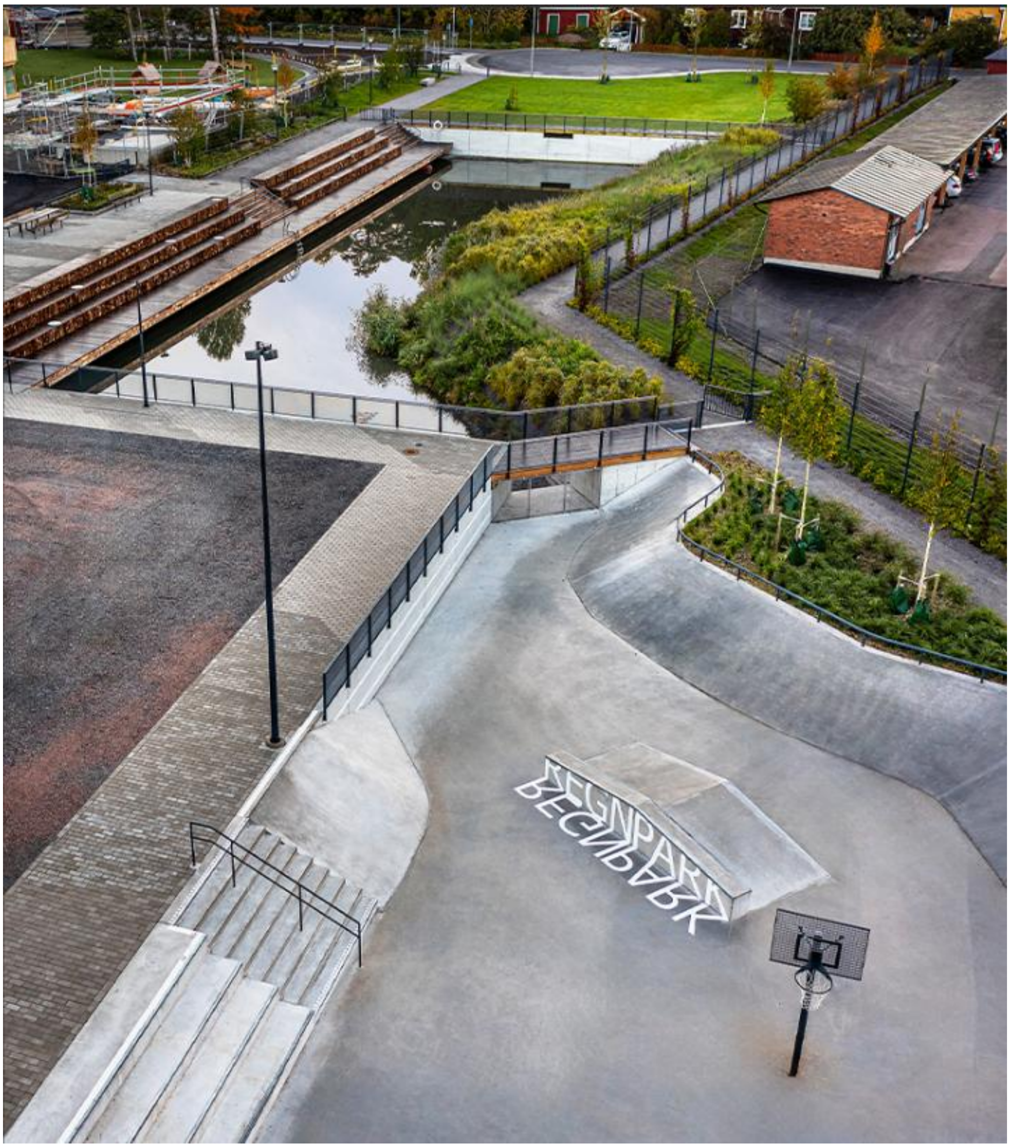

Figure 7: The pond in Elsa Eschelssons park, aerial view from the west (Illustration: Jann Lipka (Karavan Landskapsarkitekter, u.d.))

On the southern side, where vegetation is present, the pond has an incline between 1:2 and 1:3. To the north, a wooden dock with terraces frames the water surface. The western and eastern sides of the pond are bordered by concrete walls, with a passage under a pedestrian bridge at the western end to allow water to flow into the floodable activity area (Karavan Landskapsarkitekter, u.d.).

The bottom of the pond is double lined with geotextile and covered with crushed rock. Under normal water levels, infiltration into the groundwater is prevented. However, during extreme rainfall events exceeding a 10-year return period, water can overflow the pond wall at the eastern end and spread into the park's lawn, allowing natural infiltration. The pond can hold approximately 790 m³ of water, and nearly double that amount when the activity space is fully flooded (Karavan Landskapsarkitekter, u.d.). The depth at the permanent water level is approximately 1.2 meters, and at the high-water level, it is 2.3 meters (Karavan Landskapsarkitekter, 2019).

3.1.5 Ultunaallén

It is part of the four SWP that are proposed at the Uppsala tram extension (Norconsult Sverige AB, 2024b). From them, the Ultunaallén pond has been in operation since 2009. The main purpose of this pond is flow regulation and oil separation (Uppsala Vatten, 2023c). It is located in southwest Ultuna in southern Uppsala and receives water from Ulls street and another SWP in Veterinärvägen to the north (Uppsala Vatten, 2023c). Water flows from the pond eventually to Fyrisån.

For more than a century, the surrounding area has been used for research, teaching and agricultural production by several agricultural schools (Norconsult Sverige AB, 2024b). The area surrounding the pond has low vegetation, with an open grass area adjacent to horse paddocks belonging to the SLU University Animal Hospital as seen in Figure 8. The street that borders the pond to the south also drains to the pond. The new tram line is planned to be constructed in the southern adjacent side to the pond. It is expected that the pond receives drainage water from the new pathways, bicycle lanes in the surrounding area (Ibid). However, though water from the tramway is not intended to be led to the pond, pollution is expected to increase due to the current water surface being dimensioned for current conditions (Norconsult Sverige AB, 2024c).

In the report performed by Norconsult (2024b) it is observed that the slopes of the pond are maximum 1:6, it has an average depth of 1.2 m and a permanent surface area of 2600 m^2. According to the illustrations on the same document, the pond has a pre-sedimentation section (fördamm), separated from the rest of the pond by an elevation in the soil, with slopes of around 1:3, as shown in Appendix F.

Figure 8: The pond in Ultunaallén, view from the east on October 8, 2024 (photo by Margarita Judina).

The catchment area is of 67 Ha and reduced area of 15 Ha and it's designed for a 10-year rainfall event (Uppsala Vatten, 2023c). The land use in the area corresponds nowadays mainly to roads, grass areas, arable land and larger buildings.

3.2 Data Collection

3.2.1 Water and algae sampling

A total of nine sampling events were conducted for the five SWP and the reference pond included in this study; for further detail see Table A- 1 in Appendix A. The sampling was carried out between October 2024 and mid-April 2025, with the purpose of obtaining the values for various water chemistry parameters over the study period, see Water chemistry and data analysis section. Sampling frequency was originally planned to be once per month; however, since the first sampling in October took place after a dry period, an additional sampling was conducted later the same month following heavy rainfall. Furthermore, the sampling frequency in March and April was increased to every two weeks to investigate the changes in water chemistry after ice melt and increased solar irradiation.

Water sampling was conducted using a telescopic rod to collect grab samples from the surface water. Only surface water was collected based on the assumption that the water column is mixed within the ponds since the ponds are shallow. The sampling points were chosen to be as close to the centre of each pond as possible and to have free water surface. Water temperature was also measured in situ, and the results were recorded in the sampling protocol.

Algae samples were collected directly from the ponds. Algae were collected during the first water sampling on October 8, 2024, and during the two sampling events in March to determine potential differences in algal community composition and algal condition over a period of two weeks. Algae specimens were collected from locations where they were visibly present, including the southern pre-sedimentation pond at Gottsunda Dagvattenpark, both ponds along Fjädermolnsvägen in Fullerö, and the pond in Elsa Eschelsson's Park. Additionally, on March 24, 2025, a water and algae sample were collected from a pond located north of the Ultunaallén pond, at Veterinärvägen. This pond, whose outlet discharges into the Ultunaallén pond, was sampled to assess whether nutrient levels and other water quality parameters were similar to or significantly different from those in the Ultunaallén pond.

Upon arrival at the laboratory, algae samples were placed in petri dishes and stored in a cooling room at 4°C until identification. All samples were transported to the laboratory in a cooling box to ensure sample integrity. A detailed overview of the sampling dates and types of samples collected is provided in Table A- 1, in Appendix A.

3.2.2 Visual assessment of the catchment areas

Visual inspections of the areas surrounding the SWP were conducted through field visits, either on foot or by car, depending on accessibility. These assessments aimed to gain an overview of each catchment area and included the identification of pond inlets and outlets, open channels, presence of sedimentation wells or pre-sedimentation structures, surrounding vegetation, and the characteristics of the built environment. Photographs were taken using a smartphone camera to document key features.

More thorough inspections were carried out on two occasions: on 10 February 2025, in connection with water sampling, and on 10 March 2025, with a focus on the Gottsunda area.

3.2.3 Stakeholder consultations

Stakeholder consultations were conducted through online meetings and email exchanges with professionals working in stormwater management and possessing knowledge of the specific sites included in this study. Respondents were selected based on their expertise and professional affiliation.

Several online meetings were held, including discussions with a stormwater strategist from Tyresö Municipality, who provided detailed information on specific SWP in Tyresö, as well as broader insights into stormwater system maintenance, monitoring, and construction. Communication with a consultant from WRS focused on Gottsunda Dagvattenpark, given WRS's role in designing this SWP. Key topics included prior land use, construction details (such as the removal of topsoil), and current catchment area conditions. Additionally, exchanges with a park engineer from Uppsala Municipality addressed green space maintenance around SWP, covering routine maintenance practices, frequency, and fertilization methods. The information obtained through these communications was summarized and can be found in Appendix B. The findings were used as supporting information in the assessment and discussion.

Further insights were gathered through email correspondence with representatives from academia and several municipalities, including Staffanstorp and Ystad, which had reported issues with algal growth in SWP. These exchanges provided information on possible mitigation strategies and control methods in use. Additionally, personal communication with an investigation engineer from Uppsala Vatten, along with data from relevant documents, was integrated into discussion and assessment.

Short summaries of discussions with experts are presented in Appendix B along with the list of contacts shown in Table B- 1.

3.3 Laboratory Analysis

3.3.1 Water chemistry and data analysis

Water quality analysis was performed on the collected water samples to assess key physicochemical parameters, including temperature, pH, conductivity, turbidity, and alkalinity, as well as nutrient concentrations such as TN, TP, NH_4^+, NO_2^-+NO_3^-, and PO_4^{3-}. The analyses were conducted at the accredited Erken Laboratory, Uppsala University, utilizing established analytical techniques. Detailed descriptions of the methods employed and the relevant standards followed are provided in Table C- 1, Appendix C.

Additionally, surface water quality data from the sampling campaign conducted between April 2024 and October 2024 at Gottsunda Dagvattenpark was incorporated into the analysis. These analyses were carried out by Swedish University of Agricultural Sciences (SLU) within the framework of the research project Puddlejump. The data was provided by Expert contact E (2025). As the data was collected and analyzed externally, the raw data is not presented in this thesis—neither in the Results and discussion section nor in the Appendices – but it is included in the discussion in the Assessment.

The water quality data were analysed using Microsoft Excel, with graphical visualizations created to observe the status and changes of the environmental parameters over time, and to facilitate comparison between the different ponds. In addition, precipitation data for the study period were obtained from the Swedish Meteorological and Hydrological Institute (SMHI). Data were sourced from two weather stations: Uppsala Airport, representing ponds located north of the city centre, and Uppsala Central, corresponding to ponds situated closer to the central urban area (SMHI, u.d.). The graph, shown in Figure G- 1, presents diurnal temperature and precipitation data that covers the sampling period.

3.3.2 Algae observation and identification

Algae observations were recorded in conjunction with the sampling and documented in the sampling protocol in Table A- 2 in Appendix A.

To identify the genus of the most abundant species, algae samples stored in Petri dishes were examined under a microscope at magnifications ranging from 10x to 40x. An inverted microscope (HUND Willovert 30) was used for this procedure, and images of the magnified algae were captured using a smartphone camera. No specific cell count was conducted.

The identification process was based on the morphological characteristics of the observed algae, with comparisons made against available literature. The references used for species identification included John (2003), Carter-Lund & Lund (1995), searches in the AlgaeBase portal (Guiry & Guiry, 2025) and the online identification tool provided by New Zealand's Crown Research online (Manaaki Whenua - Landcare Research, 2025). Additionally, expert consultation was sought through personal communication with specialists from Hydrophyta and Naturvatten i Roslagen AB consulting companies.

As no prior expertise in algal taxonomy or formal training in species identification was available, the accuracy of the identification may be limited.

3.4 Literature Review

3.4.1 Comparative analysis of pond design parameters

The analysis of SWP design parameters was conducted by reviewing and summarizing information obtained from maintenance plans, technical documentation (e.g., construction drawings), and relevant reports. These materials were provided by Uppsala Vatten and supplemented with publicly available documents from the Uppsala Municipality website. A complete list of the reviewed documents is presented in Table H- 1 in Appendix H.

To facilitate comparison, a matrix was developed summarizing the key design aspects of each pond, such as dimensions, catchment area, amount of vegetation within the pond, and surrounding land use, among others. When perimeter and surface area data were not available in the documentation, these were obtained using the "Min karta" portal provided by Lantmäteriet (u.d.).

The comparative analysis aimed to identify structural or environmental characteristics that may influence the occurrence and extent of excessive algal growth.

3.4.2 Scientific literature

The scientific literature review was conducted using Google search engine, online search service provided by the KTH Royal Institute of Technology Library (Primo), and direct access to scientific publisher portals such as Springer, Wiley, and ScienceDirect.

Search queries were formed using technical terms related to algal ecology, water quality, growth and development in SWP, stormwater management and mitigation strategies. Commonly used keywords included "algal blooms", "stormwater ponds", "nutrient removal", "nutrient cycling", "pond maintenance", "water quality", and "urban stormwater design", among others. Additional terms explored specific control strategies, such as barley straw, pond dyes, and chemical control of algae. Multilingual searches were also performed in an attempt to include broader international research perspectives.

The literature reviewed encompassed peer-reviewed journal articles, academic books, case studies, and relevant master's and doctoral theses focused on algal growth, nutrient dynamics, and mitigation strategies in stormwater systems.

3.4.3 Assessment of the studied ponds

A case-specific assessment of the studied ponds was made to identify potential triggers for excessive algal growth in each pond. It was carried out by synthesizing all the information that was acquired through field observations, laboratory analyses as well as through literature review and stakeholder consultations. The assessment intends to undertake a detailed analysis of the conditions in each pond, revealing possible triggers for excessive algae growth. Evaluating the ponds individually made it possible to formulate tailored management recommendations based on the identified causes and best practices from the literature. The compiled data for each pond was also compared to that of the reference pond, which has not experienced significant algal issues.

3.4.4 Limitations

There are several limitations that have influenced both the process and the scope of this study. The most significant is the timing of the sampling, which did not include the summer months when algal growth is typically at its peak and more likely to become a nuisance.

Additionally, some relevant insights could not be included due to a lack of response from certain external companies involved in maintenance of the ponds. The absence of this information may have limited the depth of contextual analysis and reduced opportunities to cross-validate the observed results.

Another limitation is the monthly sampling frequency for the determination of water chemistry, which may not fully capture short-term fluctuations in nutrient concentrations and other key parameters. Such variability, especially following precipitation events or sudden temperature changes, could significantly influence algal growth and ecosystem dynamics but may be overlooked with a lower sampling resolution.

3.4.5 Use of AI tools

Since none of the authors are native English speakers, an AI-based language tool was used to refine the grammar and style of the text in this document.

4 Results and discussion

Results and discussion section presents the key findings of this study and is structured into three parts: a comparison of the physical characteristics of the SWP, a review and brief discussion of the water chemistry analysis results, and the identification of algal species observed in the studied ponds.

4.1 Physical comparison

Table 1 shows the results of the comparative analysis of physical parameters in the studied ponds.

Table 1: Comparative table of the physical parameters of the studied ponds.

Parameter\Pond	**Bälinge**	**Rosendal: Elsa Eschelsson Park**	**Fjädermolnsvägen, Fullerö**		**Gottsunda**	**Ultuna**
			Southern pond	**Northern Pond**		
Year established	2016	2022	2016		2021	2009
Main use(s)	Flow equalization	Purification and delay of stormwater (flow equalization)	Flow equalization		Treatment of water before it reaches Hågaån. Support biodiversity Recreational space Educational platform Research (stormwater purification, ecosystem services, sustainable water use)	Flow equalization and oil separation
Design parameters and information						
Land-use in catchment area	Houses, plots, green spaces, pedestrian and bicycle paths, and roads	Recently built: apartment buildings, school, parking lots and recreational spaces as well as rainbeds along the neighboring streets	Apartment buildings, villas, plots, kindergarten, green spaces, parking areas, walking and cycling paths and roads.		Vilas, multi-family buildings, colonies, forest, meadow land, parks and roads.	Roads, grass areas, larger buildings, and agricultural land
Catchment area (Ha)	8,2	6,6	22,3		101	67
Reduced area (Ha)	1,5	4	7,3		30	15

Parameter\Pond	Bälinge	Rosendal: Elsa Eschelsson Park	Fjädermolnsvägen, Fullerö		Gottsunda	Ultuna
			Southern pond	Northern Pond		
Retention time (h) - design event	6,5 h for design event. 8.5 h for average yearly rain	24	6,5 h for design event. 13 h for average yearly rain		24	----
Infiltration	Not intended except in case of flooding	Not intended	Not intended		There is a contact between the pond water and the groundwater in the clay layers	It has geotextile, it seems not intended but is not stated
Runoff coefficient	0,18	0,6	0,33		----	0,22
Flow (Q [lps])	17 (max outflow)	33 (max outflow 100 years), 23,2 (max outflow 10 years), 9,2 (regulation)	----	90	650 (max outflow), 25 (regulation)	1000 (max capacity)
Description and ratios						
Bottom surface level (masl)	26	30,25	29,6		7 (6,5 and 6,6 in initial and final sections respectively)	11,5 (10,7 in initial section)
Average water level (masl)	27,2	31,45	30,9		8	12,7
Average depth (m)	1,2	1,2	1,3		1	1,2
Average water level surface area (m^2)	200	880	600	700	5350	2153
Volume (m^3)	310	792	536	617	5200	2850 (~)
Length (L, m)	18	55,5	36	50	155	108
Width (W, m)	13	16	19	16	33	22
L/W	1,4	3,5	1,9	3,1	4,7	4,9
Perimeter (m)	52,0	154,0	92,0	113,0	364,0	260,0
Perimeter circle (m)	50,1	105,2	86,8	93,8	237,8	164,5
SDI	1,0	1,5	1,1	1,2	1,5	1,6
Vegetated area (m^2)	35,0	6,3	0,0	0,0	840,0	0,0
% vegetated area	17,5	0,7	0,0	0,0	15,7	0,0
% - area pond/Catchemnt	1,3	2,2	1,8		1,8	1,4
Slopes	1:5 over mean water level 1:3 below mean water level	1:15 / vertical 1:2 - 1:3 in vegetated side	1:5 over mean water level 1:3 below mean water level		1:3 and 1:5 in the western side. 1:8 in eastern side	1:6 over mean water level 1:3 below mean water level
Materials in the bottom and slopes	Crushed rock	Crushed rock	Crushed rock		Natural clay	Crushed rock
Shape observations	Oval o circular	Mostly rectangular.	Oval shape	Oval shape	Elongated shape, varied width	Rectangular

Parameter\Pond	Bälinge	Rosendal: Elsa Eschelsson Park	Fjädermolnsvägen, Fullerö		Gottsunda	Ultuna
			Southern pond	Northern Pond		
		One irregular edge				
Additional elements	Descent well before the inlet No deeper area intended for sedimentation	Descent well before the inlet No deeper area intended for sedimentation	Southern pond: 2 inlets from well (one with open channel). One outlet towards northern pond Northern pond: 3 inlets from well (one with open channel, one coming from southern pond) No deeper area intended for sedimentation		3 pre-sedimentation ponds and overflow surface (for slow percolation to the main pond) Two deeper areas intended for sedimentation : one after the weir and one towards the outlet	Descent well before the inlet Deeper area intended for sedimentation in the inlet

All the ponds were dimensioned using a 10-year rainfall event and mainly using the rational method. This method is particularly simple and easy to apply (Stephenson, 1981), defining a runoff coefficient for the catchment area. It has to be noted from Table 1 that the reference pond in Bälinge is one of the smallest ones, with a very low runoff coefficient. From the available information, the pond located in Rosendal has the highest runoff coefficient, revealing a highly impervious surface catchment area.

The reference pond (Bälinge), the Rosendal and the Ultunaallén pond, have descent wells before the inlet. Fullerö and Gottsunda ponds have multiple inlets. In Fullerö some inlets count with descent wells, while others input water through open channels covered with crushed rock. The Gottsunda pond has three pre-sedimentation ponds and a V-notch weir to let the water move to the main pond from one of the pre-sedimenters. With the exception of Gottsunda Dagvattenpark, the ponds are covered with crushed rock in the bottom and slopes.

According to Liu et al. (2021) the hydraulic residence time should be at most 14 to 50 days depending on the design guidelines that are used. For all the ponds, the turnover times for the control of the design rainfall event is of a day or less. However, none of them are intended to be emptied, which means that water remains stagnated for long periods of time during dry seasons. The laboratory results (Figure 11: Comparative graphs for various nutrient concentrations.Figure 11) show that the ponds in Gottsunda, Ultuna and

Rosendal have higher levels of P and PO_4^{3-} than the reference pond, Rosendal being significantly higher. About NO_2^- and NO_3^-, Fullerö, Gotsunda and Ultuna have higher levels compared to the reference pond, Ultuna having the highest values of TN and NH_4^+. Stagnant water with high nutrient levels or nutrient inputs, encourages the propagation and growth of algae, cyanobacteria and macrophytes in retention ponds (WEF, 2022).

Shallow water levels allow light penetration to the bottom, encouraging algae growth (WEF, 2022), but it usually permits efficient mixing of the water column and macrophyte growth (Liu et al. 2021). Deeper water levels may reduce the resuspension of sedimented nutrients but could encourage thermal stratification which implies release of nutrients from the sediments (Liu et al. 2021). In average conditions, all the ponds have water levels of more than 1.0 m, complying with the guidelines range of 1 to 3 m encountered by Liu et al. (2021). However, uncertainty comes when there is ice cover and melting in different seasons of the year, affecting the stratification patterns of the ponds (Liu et al. 2021). This could explain the observation of slightly different temperatures at two different depths during one of the sampling campaigns, though water levels below 1 m were observed in the field. This requires more data and information to confirm the mixed state of the ponds.

According to Water Environment Federation (WEF) (2022), having a vegetated perimeter around the pond allows it to absorb nutrients before water reaches the infrastructure. Thus, nutrient input can be hindered to a certain point by well-established vegetation, as it could be in the reference pond. It is uncertain if the same could be the case in Gottsunda Dagvattenpark pond. The ponds in Fullerö and Ultunaallén have presence of grass and short vegetation, which may not be enough of a barrier to prevent nutrients from reaching them directly. The pond located in Rosendal is enclosed in concrete walls, so it only has a vegetated border in one of its edges.

In regard to land use, the reference pond in Bälinge has the least varied uses, being mainly roads, houses and green spaces. The rest of the ponds receive water through pipes that come from different land uses including agricultural land in Ultuna and rainbeds in Rosendal.

In the study regarding the reduction of HAB, Liu et al. (2021) establish that relationships as the macrophyte area to surface area of a pond, the SDI and the generation of waves by the wind are the most important factors to account for. As observed, the studied ponds have less than 40% of macrophyte area and SDI values close or lower than 1,5 which, according to Liu et al. (2021) are conditions often observed in ponds where HAB occur.

According to Liu et al. (2021), having appropriate plant species as macrophytes may allow algae control, as they compete for nutrients and provide shelter to organisms that graze on algae, such as zooplankton. The macrophyte area to surface area is approximately 17,5% for the reference pond in Bälinge within the pond and close to the inlet and outlet. This presence of vegetation may be contributing to the reference pond 's conditions both through competition for nutrients with algae, and allowing uniform distribution of water in the pond facilitating nutrient removal processes as sedimentation. Gottsunda pond has approximately 15,7% of vegetated area in its borders, but no observable vegetated area within it. The rest of the ponds have minimal to no macrophyte area in their surface.

Though the main function for most of the ponds is stormwater regulation, they may have a possibility to remove sediments and nutrients from stormwater to a certain level. Liu et al. (2021) found that the pond area should be approximately 3% of the impervious catchment, in order to boost pollutant removals. In table xx this calculation shows the percentage of the reduced catchment area that represents each of the ponds. Their values vary from 1.3% to 1.8%, with the reference pond having the lowest value.

In regard to the shape of the ponds, an SDI value of 1.2 is recommended to help reduce the presence of HAB (Liu et al. 2021). In Table 1 it is shown that the ponds in Bällinge and Fullerö have an index close to 1.0 while the other three have an index close to 1.5. however, from all the studied ponds, the one that has the most irregular shape is in Gottsunda, since the others are very close to round-shaped, or mainly rectangular.

The aspect ratio of each pond was determined in Table 1. Liu et al. (2021) found that the suggested aspect ratios according to the existing guidelines vary from 2:1 to 6:1. An aspect ratio of 2:1 reduces the sedimentation in stagnated areas of the pond by 50%, which promotes the accumulation of algae layers (Liu et al. 2021). It is noticeable that the pond in Bälinge has the lowest aspect ratio, and the southern pond in Fullerö has an aspect ratio lower than 2:1, which is consistent with the SDI. The rest of the ponds have aspect ratios according to the suggested values.

4.2 Water chemistry results

The results of the water chemistry analysis are presented in Figure 9 and Figure 10. Figure 11 displays comparative graphs for pH, conductivity, turbidity, and alkalinity. Although the sampling period did not coincide with the peak of algal growth, the measured water chemistry parameters still offer valuable insights into the influence of nutrients from the surrounding catchment areas. Additionally, they provide an early-season indication of nutrient availability, which is crucial since algae are rapid growers and strong competitors that can quickly exploit elevated nutrient levels.

The pH of the samples ranges from 6.7 to 8.6, with the reference pond showing the lowest pH and alkalinity values. This may indicate that the pond primarily receives rainwater with minimal influence from urban or agricultural runoff that can make the incoming water more alkaline, eventually increasing the pH (Charlson & Rodhe, 1982).

In contrast, Gottsunda Dagvattenpark and the pond at Ultunaallén consistently exhibit pH values above 7.5 throughout the entire sampling period. These ponds also show higher conductivity levels, ranging between 30 and 60 mS/m, along with elevated turbidity and alkalinity values. In the case of Gottsunda Dagvattenpark, these results may be linked to the presence of clay-rich soils in the pond bottom and the surrounding catchment, particularly in the Gottsunda Gipen area (SGU, 2023). For Ultunaallén, the elevated values could be attributed to runoff from nearby horse paddocks and pastures, parts of which can be seen in Figure 8. Moreover, elevated turbidity in Ultunaallén pond can be caused by the resuspension of sediments due to the reported presence of fish (Segerlind & Östberg, 2024).

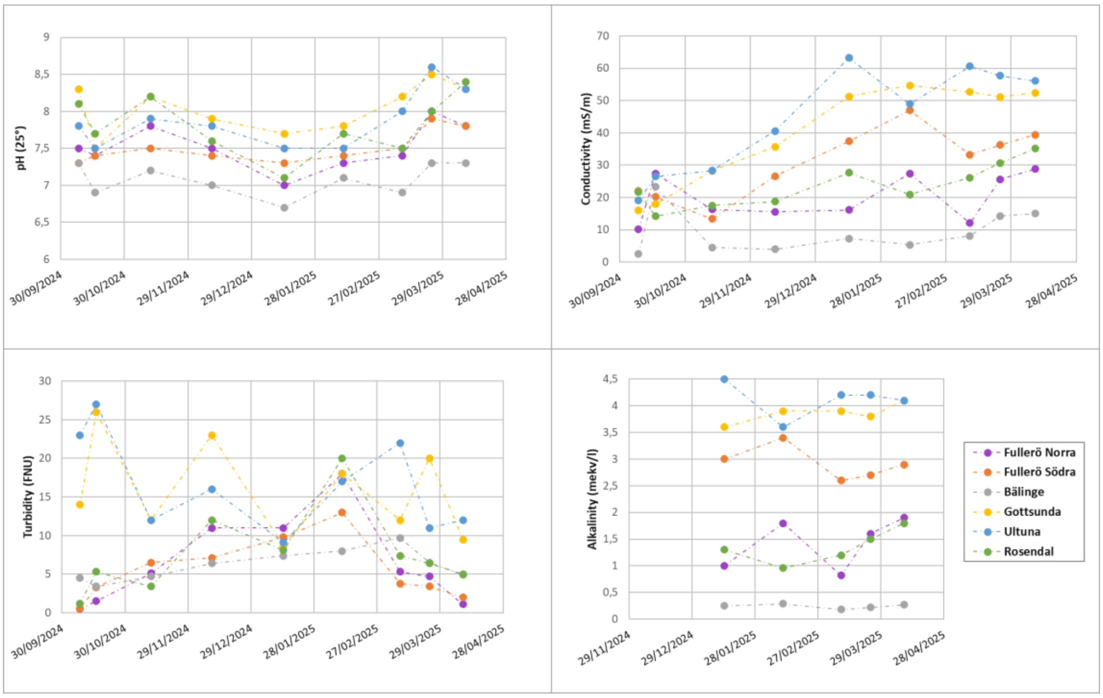

Figure 9: The results of pH, conductivity, turbidity and alkalinity measurements in the studied SWP.

A seasonal increase in both pH and conductivity can be observed during the spring months. This is often associated with the onset of the spring diatom bloom, as diatoms absorb CO_2 during photosynthesis, which can raise the pH of the water (Goldsborough & Robinson, 1996).

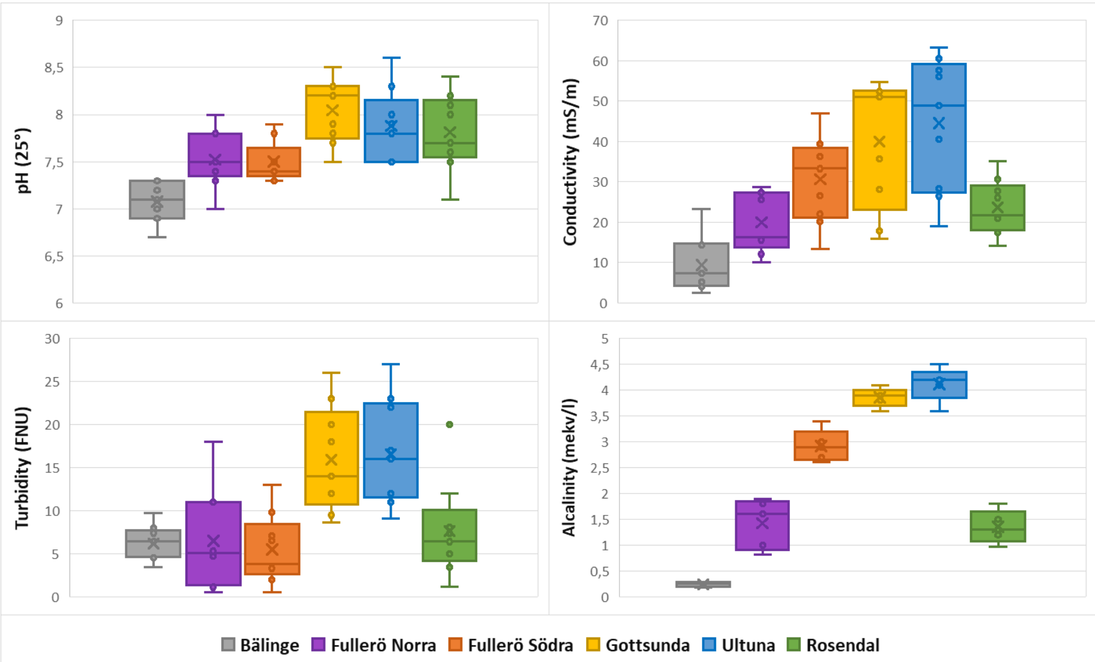

Figure 10: Comparative box plots for pH, conductivity, turbidity and alkalinity.

Turbidity levels vary considerably between ponds. The ponds in Gottsunda and Ultuna show notably higher turbidity, and their patterns are quite similar between October 2024 and March 2025. The other four studied ponds exhibit a similar turbidity pattern among themselves but differ from the patterns observed in Gottsunda Dagvattenpark and Ultunaallén ponds. The reference pond shows relatively stable turbidity levels, which may indicate a generally lower input of particulate material from its catchment area. Figure 10 illustrates the span of the values of pH, conductivity, turbidity and alkalinity for better visual comparison.

Due to the wide range of measured values, the nutrient concentration results are presented on a logarithmic scale. This approach allows for clearer comparisons between the different ponds. Figure 11 displays comparative graphs for TN and TP, NO_2^- and NO_3^- concentrations, NH_4^+ and PO_4^{3-}.

It can be observed that TN concentrations are consistently higher in the Ultunallén pond, followed by Gottsunda Dagvattenpark. Both ponds have larger catchment areas compared to the other sites in the study. In the case of Ultunallén, the elevated N levels may be linked to nutrient runoff from nearby pastures and the pens of the SLU University Animal Hospital (Bydén et al. 2003). However, further investigation is needed to more accurately identify the specific sources of these nutrients, since other activities, such as fertilization of nearby gardens and parks, can have similar effects on N runoff.

Water sampled from the pond at Veterinärvägen in Ultuna, which discharges into the pond at Ultunaallén, exhibited nutrient levels comparable to those in the receiving pond. During the sampling conducted on March 24th, the TN concentration in Veterinärvägen was 550 µg/L, closely matching the 570 µg/L measured in Ultunaallén. In contrast, the TP concentration in Veterinärvägen was slightly higher at 78 µg/L, compared to 54 µg/L in Ultunaallén. This difference is largely attributed to a higher concentration of PO_4^{3-}.

Interestingly, the chlorophyll-a concentration, used as an indicator of algal biomass in the water column, was almost twice as low in Veterinärvägen (17.8 µg/L) compared to Ultunaallén (28.8 µg/L). These differences may be attributed to the presence of FA in the pond at Veterinärvägen, which were observed attached to the stony bottom but not included in the water sample analysed for chlorophyll-a. In contrast, no such FA were noted in the Ultunaallén pond, where the higher chlorophyll-a concentration might reflect a greater presence of suspended or planktonic algae in the water column suggesting different states of these two ponds (Goldsborough & Robinson, 1996). Further details on the results from the Veterinärvägen pond can be found in the laboratory report with number 25-68 in Appendix D.

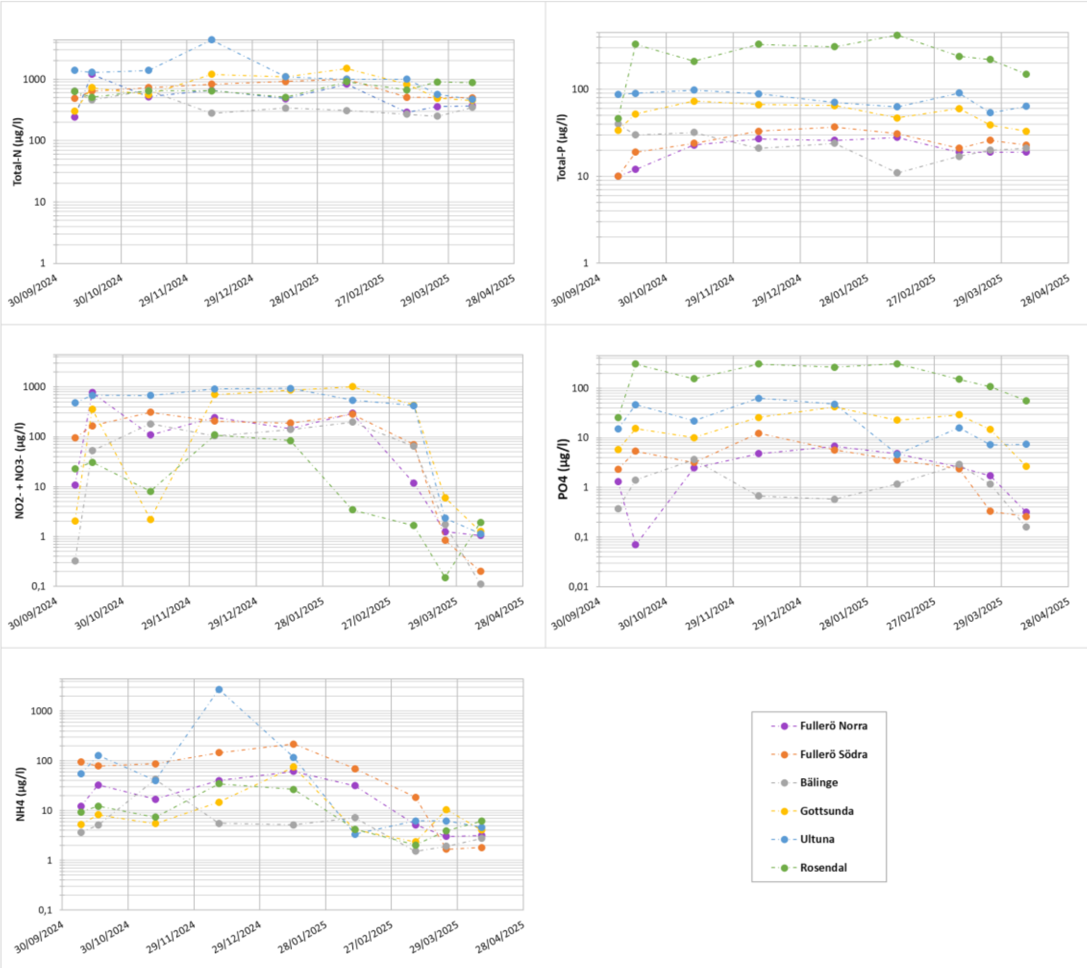

Figure 11: Comparative graphs for various nutrient concentrations.

The results also indicate that, as water temperatures rise and biological activity increases, concentrations of NH_4^+ and $NO2^-+NO_3^-$ decrease across all ponds, as these nutrient forms are typically consumed first during algal growth. A similar trend is observed for PO_4^{3-} concentrations. The decline in dissolved nutrient levels, that can be further on explored in Figure 12 and Figure 13, coincides with a period of increased solar irradiation, higher temperatures, and minimal precipitation, as shown in Figure G- 1 in Appendix G.

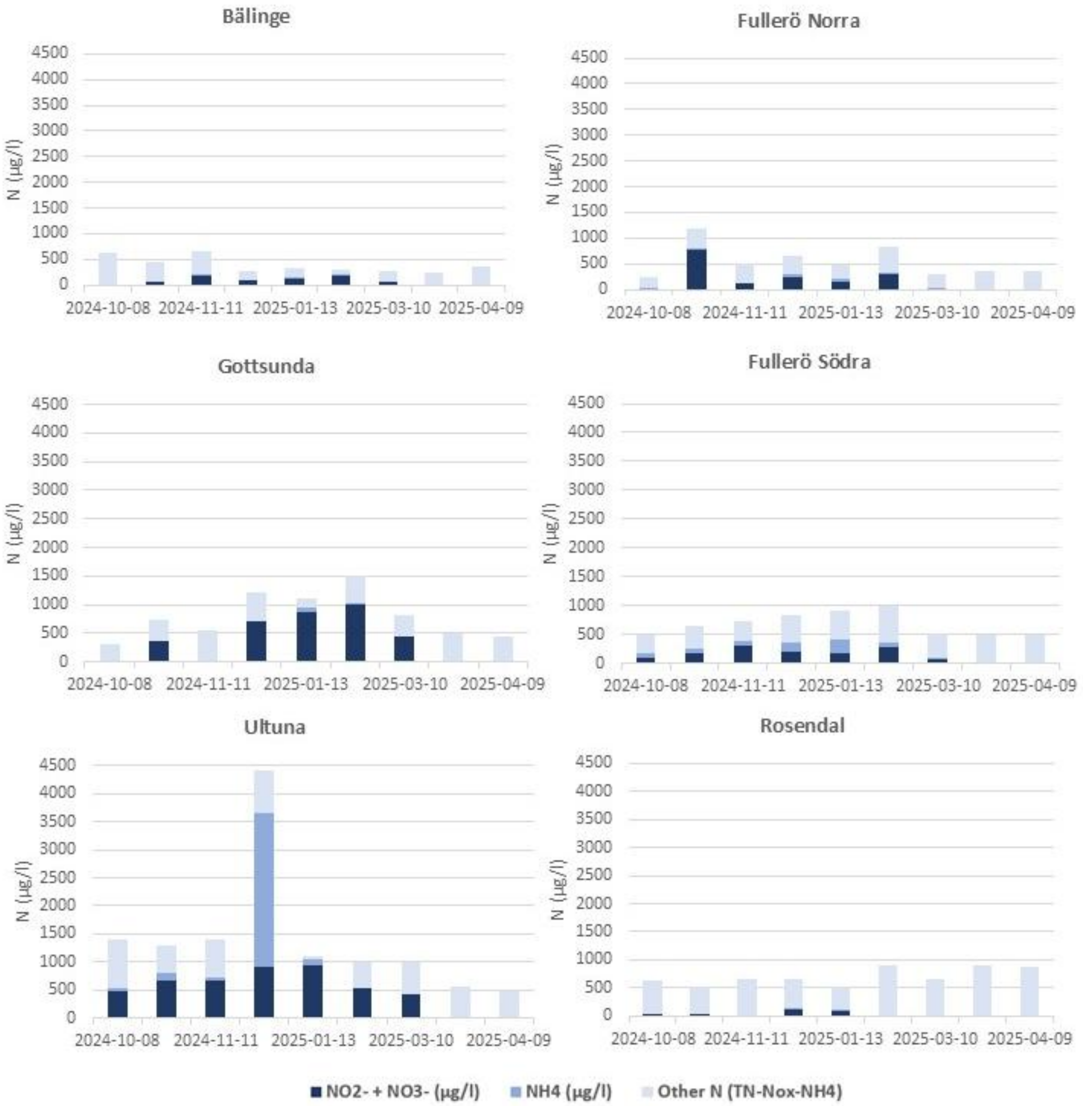

Figure 12: Temporal dynamics of N species in monitored ponds.

It is important to note that consistently higher PO_4^{3-} concentrations were observed throughout the entire sampling period in the pond at Elsa Eschelssons Park. In contrast, $NO2^{-}$+NO_3^{-} and NH_4^{+} levels were lower compared to the other ponds. This resulted in the lowest N:P ratio among the studied ponds, as shown in Figure E- 1in Appendix E, which may indicate conditions favourable for the proliferation of FA (Stevenson, 1996).

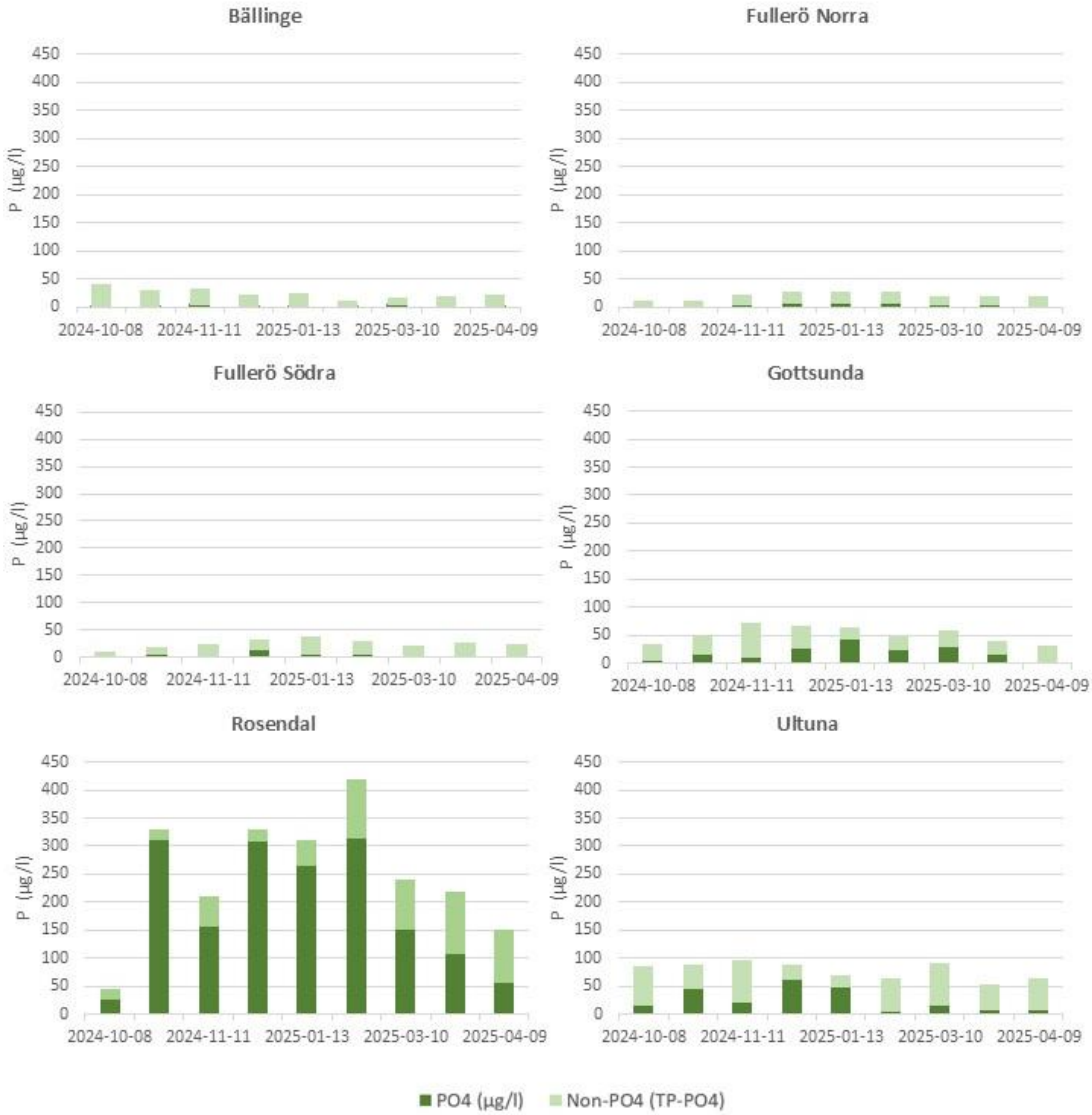

Figure 13: PO4-P as a fraction of TP in monitored ponds.

Nevertheless, both ponds in Fullerö, where algae were present, exhibited higher N:P ratios, shown in Figure E- 1 in Appendix E, compared to the other ponds, with the southern pond having the highest ratio overall. This suggests that nutrient availability and N:P ratios alone cannot fully explain the presence or absence of algae, indicating that other environmental factors play a significant role in algal development. The fact that some species of green algae, such as Zygnemataceae, can be found in oligotrophic and even acidic environments can also support this observation (Hall & McCourt, 2017; Wei et al. 1989).

4.3 Algae identification

During the first sampling on October 8, 2025, green FA were found at three sampling locations: Elsa Eschelssons Park, Gottsunda Dagvattenpark, and the ponds at Fjädermolnsvägen. Both ponds at Fjädermolnsvägen in Fullerö were partially covered with mats of FA. The southern pond had more abundant coverage, while the northern pond had less. In Gottsunda Stormwater Park, no FA were observed in the main pond; however, they were found in the southern pre-sedimentation pond. In the pond in Elsa Eschelssons, a green-yellow algal mat covered approximately half of the water surface.

The most abundant alga in the sample obtained from the northern pond at Fjädermolnsvägen was presumably identified as belonging to the genus *Zygnema* sp. (family: Zygnemataceae) due to its characteristic star-shaped double chloroplasts in each cell and lack of branching. The algae species found in the southern pond were presumably identified as *Spirogyra* sp. (family: Zygnemataceae) by observing the spiraling chloroplasts in cylindrical cells, as well as *Mougeotia* sp. (family: Zygnemataceae), *Rhizoclonium* sp., and *Cladophora* sp. (family: Cladophoraceae), as seen in Figure 14.

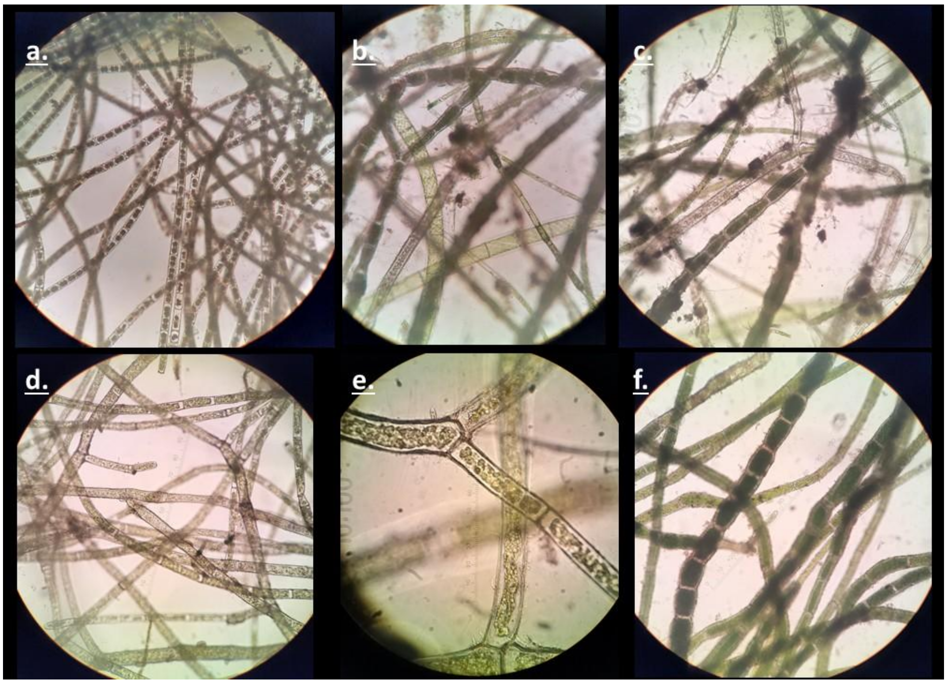

Figure 14: Various algae sampled at 8th of October 2024. ***a.*** *- Northern pond, Fjädermolnsvägen (optical magnification ×10);* ***b.*** *and* ***c.*** *– southern pond, Fjädermolnsvägen (optical magnification ×10);* ***d.*** *and* ***e.*** *– pond in Elsa Eschelssons park (optical magnification ×10 and ×40);* ***f.*** *– Gottsunda Dagvattenpark (optical magnification ×10). (photo by Margarita Judina)*

The algae found in Gottsunda Dagvattenpark and pond in Elsa Eschelssons park felt rough to the touch, indicating the absence of a mucilage layer, which is characteristic of the Cladophoraceae family. Almost no branching was observed in the specimen from Gottsunda Dagvattenpark, but the combination of barrel-shaped cells, thick cell walls, and cell size suggests that it is predominantly *Cladophora* sp. The lack of branching may be explained by the standing water environment and absence of strong currents. As for the species found in pond in Elsa Eschelssons, branching was present, which, along with cell size and roughness to the touch, suggests that it can belong to the Cladophoraceae family but the identification is uncertain.

The second sampling of algae took place on March 10, 2025. Due to the mild weather over the preceding two weeks, the ice cover had melted, revealing some newly grown FA in the same locations as observed in October 2024. An algae mat, composed mainly of freshly grown algae, had already begun forming on the surface of the pond in Elsa Eschelsson's Park. The algal species identified in Figure 15 appear to be *Cladophora glomerata*, based on observed characteristics such as cell size, cell wall thickness, and the distinctive sideways protrusion of new branches. Additionally, some invertebrate species were found among the algal samples, including a large number of *Asellus* and larvae presumed to belong to the family *Ceratopogonidae*.

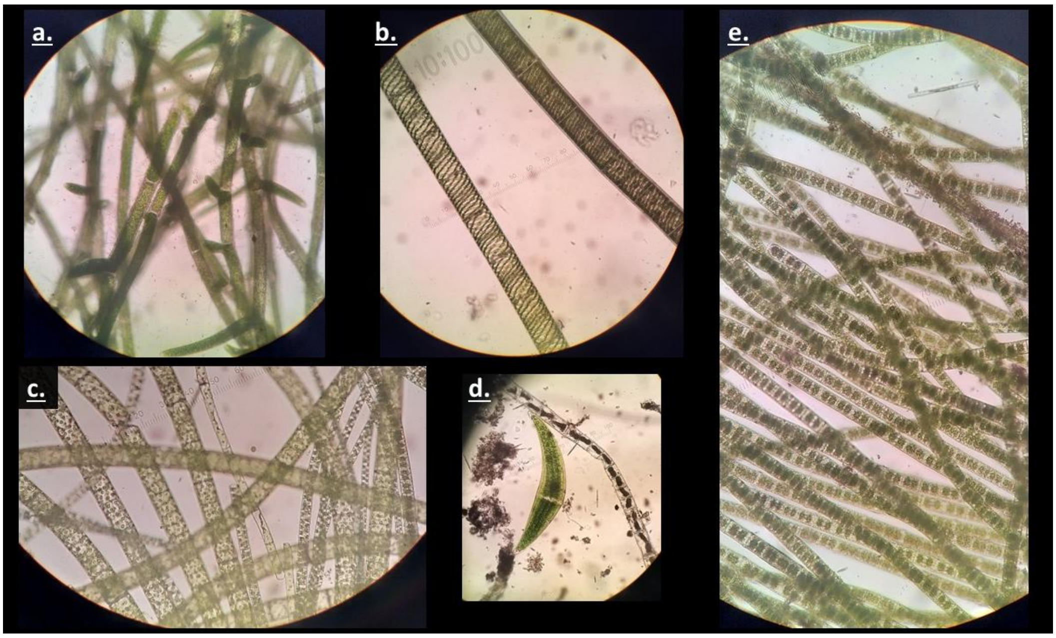

Figure 15: Algae sampled in various locations on 10th of March 2025. ***a.*** *- pond in Elsa Eschelssons park (optical magnification ×10);* ***b.*** *– Gottsunda Dagvattenpark (optical magnification ×10);* ***c.*** *and* ***d.*** *- southern pond, Fjädermolnsvägen (optical magnification ×10 and ×40);* ***e.*** *– Northern pond, Fjädermolnsvägen (optical magnification ×10). (photo by Margarita Judina)*

In Gottsunda Dagvattenpark, algae were found only in the southern pre-sedimentation pond, as in the first sampling. The algae appeared smooth to the touch, seemingly unbranched, and resembled long hairs. These were identified as *Spirogyra* sp. and are shown in Image b., Figure 15.

The algae found in the southern pond at Fjädermolnsvägen in Fullerö included *Mougeotia* sp., *Spirogyra* sp., and *Zygnema* sp. Additionally, a unicellular desmid alga, *Closterium* (family: Closteriaceae), was observed (shown in Image d., Figure 15). The algal community in the northern pond was once again predominantly composed of *Zygnema* sp., as shown in Image e., Figure 15. It is important to note that some remnants of last year's *Metaphyton* were observed in both ponds in Fullerö as well as in the pond at Elsa Echelsson's Park. These dying or dead algae were noticeably different in colour from the freshly developed algae in these ponds.

The last algae sampling was conducted on the 24th of March. For the first time, algae were collected from the main pond in Gottsunda Dagvattenpark. These specimens were coarse to the touch and exhibited branching. Based on cell size and structural characteristics, the algae are likely members of the *Cladophoraceae* family, as seen in Figure 16. Diatoms were also present in the sample.

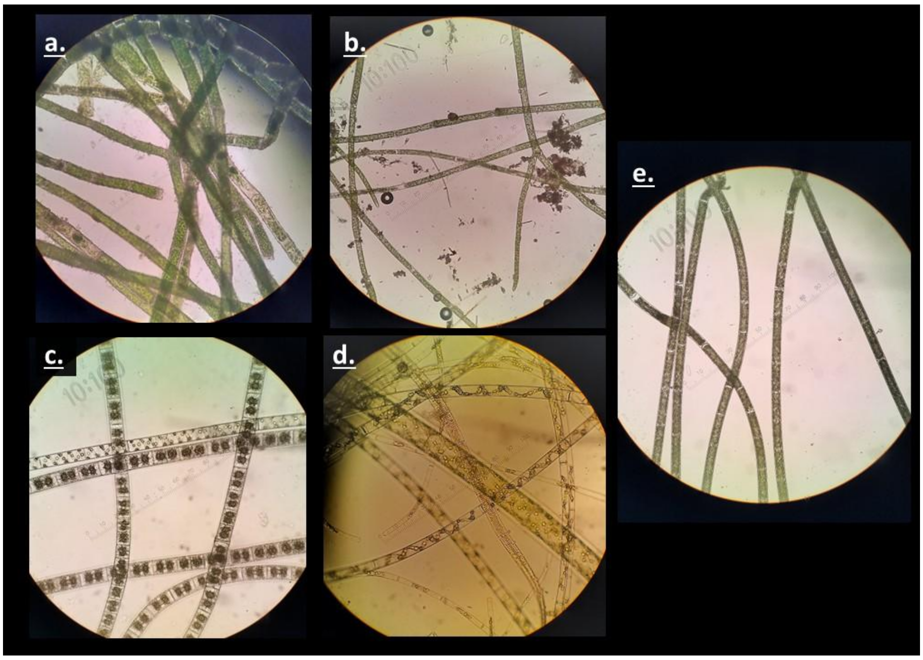

Figure 16: Algae sampled in various locations on 24th of March 2025. ***a.****- pond in Elsa Eschelssons park (optical magnification ×10);* ***b.*** *- Gottsunda Dagvattenpark, main pond (optical magnification ×10);* ***c.*** *- northern pond, Fjädermolnsvägen (optical magnification ×20);* ***d.*** *- southern pond, Fjädermolnsvägen (optical magnification ×10);* ***e.*** *– pond at Veterinärvägen in Ultuna. (photo by Margarita Judina)*

The ponds in Fullerö, as during the previous sampling, exhibited a similar algal composition. In the southern pond, some diatoms such as *Fragilaria* were observed, while the northern pond contained *Spirogyra* in addition to the previously identified *Zygnema*. The pond at Elsa Eschelsson's Park also showed no change in algal species composition—no new species were observed. However, a seemingly fresh mat of FA had begun to form along the shore where the decorative plants are located, suggesting early seasonal growth. It is worth noting that there appeared to be a greater presence of fresh, actively growing algae in the eastern, shallow part of the pond compared to earlier visits. This increase is likely attributable to the recent mild, sunny weather and rising daytime temperatures, as shown in Figure 17.

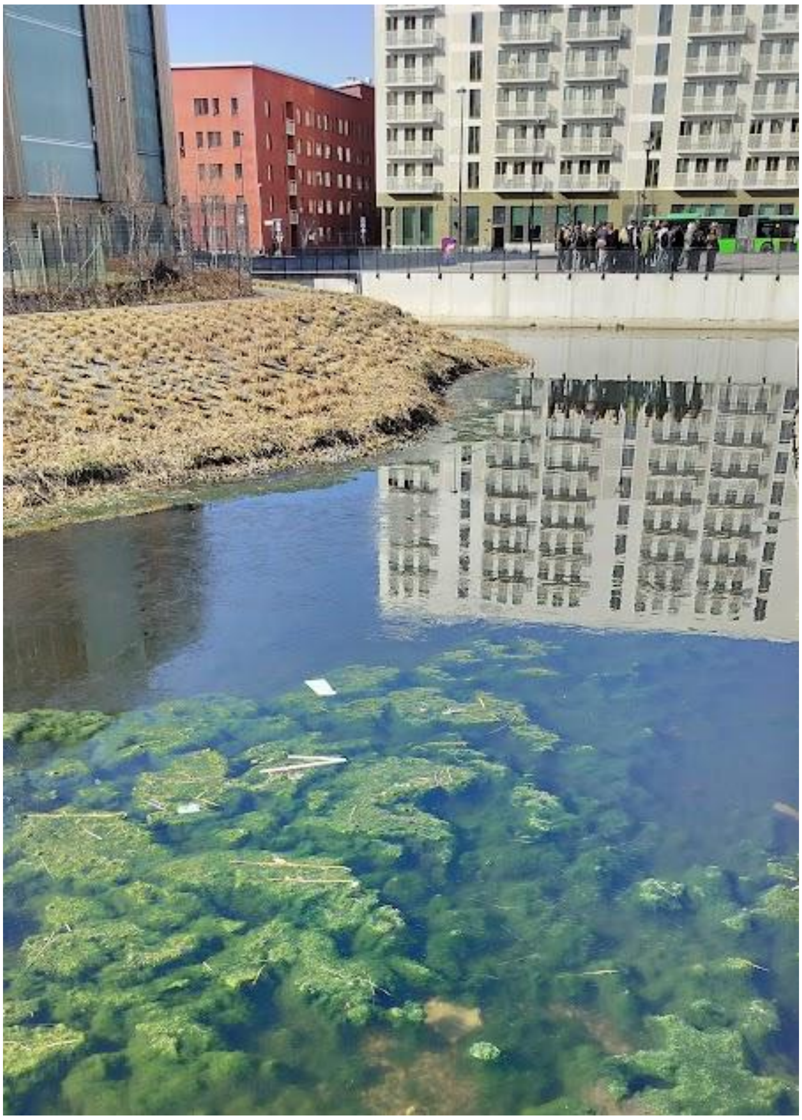

Figure 17: Algal growth observed in pond in Elsa Eschelssons park on 24th of March 2025. (photo by Margarita Judina)

During the final sampling, algae samples were also collected from the pond located along Veterinärvägen in Ultuna, which discharges into the pond at Ultunaallén. Algae were found attached to crushed rock substrates. Laboratory analysis revealed unbranched filaments with long, cylindrical cells measuring approximately 60–120 µm, containing multiple chloroplasts—a characteristic feature of the *Cladophoraceae* family. The observed wall thickness and lack of branching suggest that the algae may belong to the genus *Rhizoclonium,* shown in Figure 16.

5 Assessment

To perform an assessment for the ponds, the main aspects to account for were reviewed altogether, using subjective color-coding for illustrative purposes. Figure 18 summarizes the classification criteria used in the assessment. Green color was assigned to the characteristics that were considered adequate to avoid FA growth in SWP, while red represents those which could enable excessive FA growth. Yellow was assigned for intermediate qualifications for these characteristics, when considered adequate.

	L/W	SDI	TN/TP
✓	>2	> 1,2	010-017
±	----	1,2	----
×	<2	<1,2	>17 or <10

	Year	Algae (qualitative obs.)
	> 10 yrs	None observed
	5-10 yrs	In pond or presedimenter
	< 5 yrs	Cover >50% surface

	TP and TN
↑	Oligotrophic or mesotrophic
↑↑	Eutrophic
↑↑↑	Hypereutrophic

Figure 18: Classification criteria and color-coding for the main parameters to perform the SWP assessment.

Since older ponds tend to experience less issues with algae, ponds with less than 5 years constructed are considered at higher risk of developing algal mats. Gentle slopes in the borders and the presence of sedimentation areas are considered beneficial to avoid algal mats in ponds, as acknowledged in the literature review in section 2.1. Similarly, an aspect ratio over 2 and SDI over 1.2 are recommended in stormwater pond design, as well as an irregular shape and the presence of macrophytes in the neighboring area.

Nutrient levels were also accounted, as mentioned in section 2.1, N and P concentrations representing eutrophic conditions were considered the baseline for SWP, thus color-coded in yellow. Lower nutrient levels would be represented in green and higher in red. The TN:TP ratio between the limits according to the literature review for nutrient limitation were considered positive to avoid the presence of FA mats, while other values would be considered negative.

Finally, the classification of the presence of algae was merely a subjective choosing, based on the field observations.

Table 2 corresponds to a basis for the assessment of the SWP in this study. Contrasting results can be observed in the reference pond, and in the rest of them. Interestingly, FA growth in SWP can be present in spite of the compliment of many recommendations and lower nutrient levels. The assessment for each SWP is presented in detail in the following sections.

Table 2: Summary of the SWP assessment.

	Bälinge	Fullerö Södra	Fullerö Norra	Rosendal: E.E. park	Ultuna	Gotsunda
Year	2016	2016		2022	2009	2021
Gentle slopes	✓	✓		×	✓	✓
Sedimentation	×	×		×	✓	✓
L/W >2	×	×	✓	✓	✓	✓
SDI	×	×	±	✓	✓	✓
Long and irregular*	×	±	±	×	×	✓
Macrophytes	✓	×	×	×	×	✓
TP	↑	↑	↑	↑↑↑	↑↑	↑↑
TN	↑	↑↑	↑	↑↑	↑↑	↑↑
TN/TP	✓	×	×	×	✓	✓
Algae *	-----	Zygnemataceae	Zygnemataceae	Cladophora	----	Cladophora

* Subjective observations

5.1 Ekåkersvägen in Rörby/Bälinge

The reference pond was built in 2016, becoming a well-established pond with gentle slopes in its borders. Some macrophytes of *Potamogeton* genus emerge to the surface, occupying close to 20% of the pond's surface area. Reeds grow at the inlet and outlet of the pond potentially forming a biological filter and promoting a uniform distribution of the flow in the pond.

The pond in Bälinge is the only pond in the study having a security fence around it. Though the pond is reachable through unlocked gates, it limits direct interaction from the public. Apart from a fence, the pond is surrounded by grass and vegetation which probably hinders part of the nutrients that could be input from the roads nearby.

The land use of the catchment area in this pond is less varied in comparison with other ponds in this study and the reduced catchment area is the smallest. In the surrounding area, house owners may handle runoff from the house roofs on their own, so there is a possibility that part of this water is not reaching the pond.

No FA were found in the pond during the sampling campaigns, but water quality results suggest that the main primary producers of chlorophyll are microalgae, phytoplankton and macrophytes.

The TP parameter suggests that the pond is mainly mesotrophic, so it has moderate levels of biological productivity and nutrients. The N:P ratio shows that often N and P are limiting to the algal growth, however, on some occasions

P becomes the limiting factor then the ratio increases. However, reference pond has the lowest PO_4^{3-}, TP and TN levels among all the ponds in the comparison.

This pond has some design elements like no natural shading, an elongated but close to round shape, with a low aspect ratio and SDI close to the unit, and the bottom material (crushed rock) that could be counterproductive if the nutrient levels in the runoff would rise. However, as lower nutrient amounts reach the pond, it has been able to achieve some ecological balance where FA are not proliferating.

5.2 Elsa Eschelssons Park

Throughout the study period the pond in Elsa Eschelssons Park had the presence of FA and no mechanical removal was made. The design of the pond seems to benefit algal growth because the water surface is enclosed in concrete walls from three sides making it sheltered from the wind. Despite its high aspect ratio, which facilitates good hydraulic efficiency, the pond lacks an irregular shape. The southern side, where decorative vegetation is planted, features some gentle curves. However, the rectangular design results in corners where stagnant water may accumulate, potentially promoting algal growth.

Additionally, the section of the pond near the inlet, in the eastern part, is very shallow, with an observed water level of approximately 20 cm deep. On sunny days, the concrete and the crushed stone in the bottom of the pond might additionally raise the temperature of the water. The lack of movement coupled with higher temperature is benefiting the proliferation of algae. This can explain the early development, observed in March-April, of the new-grown algae mat in this pond in comparison to other studied ponds.

Higher temperature and sheltered state can also influence the rate of evaporation and, during the periods of low or no inflow, the water level can drop more in comparison to other ponds, exposing the stony bottom to the solar irradiation, promoting the algal growth in the bottom. The stony substrate is another feature that is favourable for the establishment and growth of benthic algae such as *Cladophora Glomerata,* and disadvantageous for the development of biota and herbivory.

The absence of aquatic macrophytes gives additional advantage for the benthic FA since there are no other outcompeting primary producers, no natural shading and, arguably, lack of grazers. The absence of slopes is another design feature that does not allow the establishment of vegetation which can promote shading, nutrient uptake and support biodiversity.

The chemical analyses of the water samples gathered from this pond have consistently shown elevated PO_4^{3-} concentrations which is presumably the primary cause of FA occurrence. Among the studied ponds, the pond in Elsa Eschelsson park has shown the lowest N:P ratio, which can potentially indicate a more favourable nutrient composition for FA growth. The high P concentrations in this pond suggests a hypereutrophic state.

The area surrounding the pond, as well as part of the catchment, is still under construction, making it difficult to identify potential additional sources of nutrient runoff. However, personal communication with an Expert contact L (2025), who is a researcher at SLU that has specific knowledge of the maintenance practices of green spaces in Rosendal, revealed that nutrient leakage from the rain beds draining into the pond may be occurring. This is partly due to leakage from the substrate used in the rain beds, particularly the compost, and in some cases, biochar fraction added to support the planted vegetation (Pettersson Skog et al. 2023; Pettersson Skog, 2024). According to an Expert contact L (2025), another possible contributing factor is the rain bed design in Rosendal, with very short retention times, that limits the treatment of dissolved nutrients.

Additionally, all planted vegetation in both plant and rain beds in the surrounding area have been maintained under a warranty period, made by the construction company, which includes routine watering with a fertilizer solution. Although the maintenance guidelines specify that only trees in the plant beds, which are not classified as rain beds, may be fertilized, fertilizer application has reportedly occurred across all beds (Expert contact L , 2025).

During the course of this study, several attempts were made to contact the construction company responsible for building the pond and stormwater drainage system in Elsa Eschelssons Park. The aim was to obtain detailed information about the warranty maintenance and the specific design and construction of the rain beds in the catchment area. However, no response was received.

Recommended control measures

It was identified that one of the probable main causes for extensive algae growth in the pond in Elsa Eschelssons Park is the transport of nutrients, specifically P. Therefore, measures to reduce P levels should be prioritized. Establishing improved communication between different actors to prevent unwanted maintenance measures is a key to minimizing nutrient influx.

The plantation of aquatic submerged macrophytes can be one of the methods to regulate the concentrations of dissolved nutrients and to control the algal growth by providing shading. Furthermore, the shallow section of the pond could be converted into the wetland, acting as a natural filter and promoting biodiversity. In addition, this recently mentioned solution can be combined with the insertion of barley straw for the promotion of macrophyte growth. Alternatively, the installation of the iron-enhanced sand filter (IESF) for P adsorption could be considered, but this might require substantial intervention in the pond for its installation and further economic assessment.

The apparently low algal diversity within the mat—consisting primarily of species from the Cladophoraceae family—suggests that introducing grazers alone may not be an effective solution. If *Cladophora* has already become established, herbivory pressure could potentially increase its abundance. This is because grazers may preferentially consume epiphytic organisms that live on the surface of the algae, rather than the *Cladophora* itself, which is less palatable due to its large cell size (Steinman, 1996).

Another potential mitigation solution is the addition of FTW, which can aid in nutrient uptake, provide shading, and support treatment processes through microbial activity in the root mats. This approach can also enhance biodiversity and, when designed to be mobile, allow for flexible deployment in other ponds as needed.

Based on the experience of Malmö Municipality, the installation of circulation pumps and/or fountains to promote aeration and water mixing can be considered (Al-Mehdawi & Jamalaldin, 2014). These technical solutions may also enhance the aesthetic value of the site by introducing visible water movement. Additionally, raising the water level through the addition of freshwater from alternative sources during periods of low summer precipitation could be explored as a complementary measure. However, the implementation of such methods should be carefully evaluated through a cost-benefit analysis to ensure their effectiveness and sustainability.

It is important to note that mechanical removal of FA, if not accompanied by a reduction in P influx, can potentially worsen the problem. There is a risk that if this procedure is performed in this pond during the summer and followed by high temperatures, it may trigger the proliferation of cyanobacteria, which thrive in warm, P-rich waters and can pose a risk of HABs. If an urgent response is needed, pond dyes can be applied as a temporary solution during the initial bloom period. These dyes reduce sunlight penetration, thereby limiting the growth of microalgae.

It is recommended to install descriptive infographics with information about stormwater management and the role of the algae in nutrient cycling and stormwater treatment for educational purposes and to raise acceptance for the algal presence since it poses mostly an aesthetic disturbance.

5.3 Fjädermolnsvägen, Fullerö Ponds

Ponds in Fjädermolnsvägen in Fullerö are considered as one whole waterbody to manage the catchment area, which has a high percentage of surface area per reduced catchment area, in comparison with other studied ponds. However, the southern pond eventually drains towards the northern one, for water to be led to the next recipient. Therefore, the northern pond is slightly bigger from the two, as it receives water from the southern pond and from other two inlets. It can be argued that, since water stored in the southern pond will eventually flow to the northern pond, the southern pond acts in a similar manner as a pre-sedimenter for the part of runoff that is caught and stored in it.

Both ponds have a similar oval shape, and each of them has an open channel covered in crushed rock which brings in a portion of the inflow. These open channels experience some vegetation growth, as observed in-situ, which could either slow down the inflow favoring undesired stagnation, or favor channeling and high velocities impacting on the sedimentation capacity of the pond. The rest of inflow points come from pipelines and their corresponding descent wells.

The ponds have gentle slopes in the borders and are open to the public. During the sampling campaigns it was noticed that the public interacted with the ponds skating or doing other recreational activities, since toys were observed in and around them.

Over the course of the sampling algae were observed floating in the water surface or frozen in the ice. This shows that no manual maintenance was done to tackle algae growth in either of the ponds. Both ponds have some reed vegetation close to the inlets and outlets, and some *Potamogeton* macrophytes were spotted along the shoreline in the northern pond. However, surface vegetation coverage is minimal in both ponds.

5.3.1 Southern pond

The southern pond exhibited greater algal coverage than the northern pond during the sampling period. Remnants of FA mats can cause shading, potentially hindering macrophyte development. Conductivity measurements were consistently higher in the southern pond compared to the northern pond from December through the final sampling in April, and also exceeded the values recorded in the reference pond. Alongside alkalinity values, approximately double those observed in the northern pond, these findings suggest that the southern pond receives water with a higher concentration of dissolved ionic compounds. This may be associated with the slightly elevated nutrient concentrations observed in the southern pond which is favorable for algal proliferation.

The FA mat, composed of multiple species, may exert an inhibitory effect on both macrophytes and phytoplankton through allelopathic interactions. This could help explain the lower turbidity observed in the southern pond. Such conditions may further promote the dominance of FA, creating a self-reinforcing cycle. Therefore, the physical removal of existing algal mats is recommended as an initial control measure. This approach would not only reduce shading but also permanently remove nutrients assimilated by the algae, thereby improving the conditions for the implementation of additional mitigation strategies.

5.3.2 Northern pond

The northern pond is slightly larger and more elongated than the southern pond, resulting in a higher aspect ratio, although the SDI values are very similar for both. The northern pond appears to be used more frequently for recreational activities, such as ice skating and hockey, likely due to its larger surface area. These activities were observed during the sampling campaigns conducted while the ponds were frozen.

The dominant algal species identified in this pond was *Zygnema*, a genus known to grow in nutrient poor environments. In addition, *Zygnema* can be found in more acidic conditions. This suggests that factors other than nutrient enrichment may be contributing to the development of filamentous nuisance algae in the pond.

During the last two sampling events, in March and April, freshly grown algae were observed on the pond bottom in shallow areas. This indicates that nutrient availability was sufficient to support algal growth during the dry and sunny conditions in March, despite the season.

Recommended control measures

Water quality parameters and the presence of algal mats suggest that the southern pond may function as an initial nutrient-removal step for the portion of stormwater it receives. However, FA from this pond may be transported downstream into the northern pond, highlighting the importance of improved maintenance of the southern pond. Physical removal of algal mats is recommended as a primary management strategy. Following this, the application of barley straw may offer a low-cost method to suppress further algal development and support the establishment of aquatic macrophytes.

Water chemistry analyses indicate that N is the limiting factor in both ponds. Incorporating wetland-like zones within the ponds or introducing macrophytes could enhance N uptake while providing habitat for grazers, such as invertebrates, that may contribute to long-term algal control.

Current interactions between the public and the ponds do not appear to negatively impact nutrient levels, based on available evidence. Nonetheless, both safety and educational considerations remain important. Establishing vegetated buffer zones around the pond perimeters is advised to discourage direct access while enhancing nutrient filtration from sources such as direct surface runoff and diverse litter. This measure would also preserve the aesthetic appeal of the site.

Given the residential context of the ponds, particularly their proximity to a kindergarten and playground, there can be a valuable opportunity to enhance public understanding. Educational signage or interactive installations could help inform visitors about the role of SWP and discourage harmful behaviors.

Lastly, as no specific delineation of catchment areas for each pond was identified, further investigation is necessary. More precise delineation of individual catchment areas would support the development of targeted management strategies.

5.4 Gottsunda Dagvattenpark

Gottsunda Dagvattenpark is a relatively newly established pond, constructed in 2021. It reportedly experienced problems with FA during the summer of 2023, when mechanical removal was carried out, and again in 2024 (Expert contact B, 2025). According to a researcher at SLU (2025), extensive FA growth is a common issue in newly constructed ponds that receive agricultural runoff. However, it is suggested that this problem may resolve over time as the ecosystem becomes more established and reaches a natural balance.

Reportedly, this pond does not receive agricultural runoff, although some agricultural land borders the northern inlet. However, there is no clear evidence that this land is fertilized. The catchment area is large and characterized by diverse land uses, which likely contributes to elevated nutrient levels in runoff. In addition, the pond receives inflow from surrounding green spaces, including fields, forests, and allotment gardens in the recreational Gottsunda Gipen area, which may also contribute with nutrients in runoff. These features support retention in the landscape, resulting in a more continuous base flow through the pond, creating an environment that resembles a wetland or shallow lake.

This is the only pond in the study with a different bottom substrate—natural clay. The analysis of the water samples revealed that pH, turbidity, conductivity, and alkalinity are relatively high compared to the other studied ponds. These elevated values may be linked to the presence of clay materials both at the bottom of the pond and within the catchment area.

The transport of clay materials from the catchment area to the main pond is partially mitigated by pre-sedimentation ponds. Notably, FA were first observed in the southern pre-sedimentation pond, which might suggest elevated nutrient levels in that specific area. Additionally, stagnant water conditions were observed in the southern pre-sedimenter, which further favors algal growth. These pre-sedimentation ponds may contribute to the proliferation of algae in the main pond, as algal mats can potentially be washed downstream.

The gentle slopes, large size, and irregular shape of the pond are features that not only support biodiversity but also enhance water treatment through sedimentation and help prevent stagnation. These characteristics are generally considered beneficial for controlling FA. Another positive factor is the ongoing establishment of aquatic macrophytes. The presence of *Potamogeton* in the main pond, along with typical wetland vegetation in the shallow shoreline areas, suggests that the pond provides favourable conditions for the development of a balanced ecosystem.

Data provided by SLU indicates that FA mats began to appear on the water surface around mid-June 2024. Precipitation records from the preceding month, between May 10 and June 10, show a total rainfall of only 23 mm, with no heavy rain events that could have influenced algal growth. This period of low precipitation coincided with a rise in air temperature, with daily averages nearing 17°C. Such conditions are favorable for the development of benthic algae. Water quality data from SLU confirms that by May 27, the pond water temperature had reached approximately 23°C, further supporting an environment prone to algal proliferation.

Interestingly, photographs submitted by the public as part of the citizen science within the project Puddlejump showed that the filamentous mats had nearly disappeared following a period of intense rainfall at the end of June. Between June 28 and 30, a total of 59 mm of rain fell over just three days, suggesting that strong hydraulic flushing played a key role in breaking up and dispersing the algal mats.

In addition, SLU data revealed that actual pond depths were occasionally shallower than the 1-meter average intended in the design. Prior to the appearance of the algae, depths typically ranged between 0.9 and 1 meter, with temporary increases during rain events. Shallower depths and stagnant water may have contributed to the establishment of FA by promoting warmer water temperatures and light penetration to the pond bottom.

During the last algae sampling, FA were observed attached to the stems of aquatic macrophytes. This attachment provides the algae with an advantage, even under turbid conditions with low light penetration. By anchoring to macrophytes, FA can proliferate more rapidly, even when environmental conditions are less favorable. Once the spring phytoplankton bloom subsides and, in the absence of turbid inflows, water claritywould likely improve. This increased clarity allows sunlight to penetrate deeper into the water column. As temperatures rise, these conditions can trigger the proliferation of benthic FA.

Recommended control measures

It is important to conduct regular monitoring of the pre-sedimentation areas, particularly the southern pre-sedimenter, which appears to experience prolonged stagnation. This stagnation can create favourable conditions for the development of thick mats of FA, which could eventually affect the main pond.

Given that one of the pond's intended functions is educational, there is an opportunity to enhance public understanding by providing more information about algae—especially their ecological role and contribution to nutrient removal from water. It is essential to acknowledge that the presence of algae is not inherently a negative indicator and does not influence the primary function of water retention. On the contrary, algae are a natural and expected component in the development of pond and wetland ecosystems. Additionally, the use of barley straw could be explored as a potential low-impact method for mitigating excessive algal growth in the pond.

If over time, excessive algal growth persists, modular alternatives such as the use of FTW could be researched and implemented in this pond. It is, however, important to allow Gottsunda pond to establish in time, since it is relatively newly constructed and still in the process of achieving ecological balance.

5.5 Ultunaallén

The pond at Ultunaallén is the oldest among those included in this comparative study, constructed in 2009. It has reportedly not experienced excessive algal growth in recent years. No sediment removal has been carried out in this pond to date. Under normal water levels, the pond reaches a depth of approximately two meters at its deepest point—significantly deeper than the other ponds in the study. This greater depth can be a limiting factor for the development of benthic algae, as light penetration is reduced, particularly following periods of turbid water inflow.

The shape of this pond is strictly rectangular, and it has the highest aspect ratio of the studied ponds, which facilitates sedimentation. Regardless of steeper incline of the slopes, in comparison with the ponds in Fullerö and Gottsunda Dagvattenpark, this pond is more exposed to the wind due to its size which can promote water movement and ultimately be bad for algae

The nutrient concentrations in this pond were relatively high during the study period. Contributing explanatory factors may include the large catchment area, diverse land use, and the potential input of agricultural runoff from nearby animal paddocks into the stormwater drainage system. Although elevated levels of TN were observed during the winter, concentrations declined throughout

March and April. This reduction led to a lower N:P ratio, which may create favorable conditions for the proliferation of FA.

Aquatic macrophytes have not been observed in this pond; however, there is evidence of fish inhabiting the area, as well as some European toads (*Bufo bufo*) (Segerlind & Östberg, 2024). The absence of macrophytes, an important food source for many aquatic animals, suggests that any algal growth in the pond may be regulated primarily through grazing by these organisms.

The deciduous maple trees at Ultunaallén provide partial shading to the pond during spring and autumn, when the sun remains at a lower angle in the sky. Moreover, during the autumn it was observed that some leaf litter is entering the pond potentially acting as an inhibiting factor for the algal growth.

Recommended control measures

Due to the plans to either expand the existing pond or construct a new one nearby in conjunction with the tram line development and considering that the current pond has not experienced excessive algal growth, no specific control measures are recommended for the existing structure at this stage. However, the planned reconstruction presents an opportunity to redesign the pond with enhanced ecological functionality, particularly to minimize the risk of FA proliferation in the future.

For future development, it is recommended to incorporate a larger wetland buffer zone into the pond, which would serve as a natural filter for nutrient-rich runoff while also providing habitat and shelter for local wildlife. Moreover, introduction of natural shading through tree planting could further help moderate water temperatures and light availability, discouraging algal overgrowth. Additionally, a more irregular pond shape could be implemented to enhance water circulation and reduce stagnation.

The inclusion of aquatic macrophytes within the pond is also advisable, as they contribute to nutrient uptake, habitat provision, and overall ecosystem balance. Prior to any redevelopment, an ecological assessment should be conducted to evaluate potential impacts on already established species and ensure their protection.

6 Uncertainties and validation

The validity of this study is limited by several factors, most notably the low frequency of water quality sampling, which was constrained by time and resource availability. Additionally, water quality parameters are not expected to remain constant or within a specific range, as they are influenced by various factors, including short-term weather patterns, land use activities within the catchment area and the dynamic nature of the ecosystem. As a result, short-term variations and long-term trends in water chemistry and algal development could not be fully captured. This introduces uncertainty in interpreting the data, particularly in relation to the temporal dynamics of algal growth and nutrient fluctuations.

Furthermore, each pond examined in this study differs in terms of age, design, catchment characteristics, maintenance practices and ecological development. These differences contribute to the formation of distinct pond ecosystems with unique biogeochemical and ecological interactions. Without more detailed, long-term monitoring and deeper analysis, it is difficult to draw definitive conclusions about the specific drivers of algal growth in each system.

The complexity of interactions between nutrient loads, physical conditions, biological communities, and external influences (e.g., catchment activities or weather events) adds further uncertainty. Given the broad scope and the limited dataset, the assessment should be considered exploratory in nature. Not all parameters necessary for a comprehensive evaluation could be measured, and the results therefore offer only a partial picture of the system dynamics.

Despite these limitations, the study provides somewhat generalized but valuable insights and serves as a foundation for further, more detailed investigations.

7 Conclusions and reflections

This thesis investigated the conditions leading to excessive algal growth in SWP, with a focus on reviewing the interactions between pond design, water quality, observed possible triggers, and suitable management strategies. Through the assessment of selected case studies and a reference pond, the study revealed that algal proliferation is not driven by a single variable, but rather by a complex combination of physical, ecological, and human-related factors. The findings provide direction for future management and planning of stormwater infrastructure, while underlining the importance of adopting site-specific, ecologically informed approaches.

Despite variations in design and layout, all the ponds comply with the design standards and guidelines for stormwater management, for their main function. While these baseline functional criteria are reportedly met, the presence of excessive algal growth in most ponds, apart from algae-free reference pond, indicates that compliance with general design standards alone may not be sufficient to prevent algal growth.

The reference pond, characterized by gently sloped shorelines, established macrophyte vegetation, and fencing that limited direct human access, illustrates how design nuances can enhance ecological stability. However, it has to be acknowledged that the reference pond's catchment area is the smallest and least varied in land-use of all. Ponds with vertical concrete edges, enclosed designs, and limited vegetation were more prone to algal issues, supporting recommendations to avoid certain configurations and materials, and promote littoral vegetation for better ecological function and algal control.

While nutrient input is a key driver to algal development in SWP, other factors, such as light availability, stagnant water, low macrophyte presence, and high temperatures, also contribute. This emphasizes the need for water quality assessments to include ecological and physical site conditions, not just nutrient levels. Importantly, algae should not be viewed solely as a nuisance since they play a valuable role in nutrient removal processes in a balanced ecosystem.

Effective management of algal growth in SWP requires a multifaceted approach that prioritizes long-term ecological stability over short-term fixes, especially in changing conditions related to weather patterns and further urban development. Preventive strategies are the most sustainable and efficient, focusing on reducing nutrient inputs and enhancing the pond's natural capacity to retain and process nutrients. A key measure is promoting macrophyte growth within and around the ponds promoting nutrient uptake, establishing buffer zones and boosting biodiversity.

Mechanical removal of algal mats in the ponds where this problem is occurring should be prioritized before other measures could be taken. For this purpose, machinery access and suitable appliances should be thought-through the layout of a pond. Mechanical removal should also be paired with broader efforts to control nutrient inputs from the source, if possible, otherwise the algae are likely to return. Ultimately, management efforts should aim to establish a more self-regulating system by implementing more frequent and adaptive maintenance during the initial years following construction, thereby supporting the establishment of long-term ecological balance.

Additionally, providing accessible information about the functions and added value of stormwater systems can help increase public acceptance of occasional algal growth. However, educational efforts should target not only the general public, but also service personnel and planning authorities. Improved communication among municipalities, construction firms, and maintenance teams is essential. A shared understanding of pond function can ensure better implementation of best practices, aligning technical, ecological, and social goals. The stakeholders around SWP and their functions should rely on accessible information to make decisions and establish behaviors towards these structures.

This study confirms that SWP must not be viewed solely as hydraulic infrastructure. They are also ecosystems whose biological communities influence water quality through interactions such as nutrient uptake, sediment stabilization, and trophic dynamics. The promotion of functional biodiversity and thoughtful vegetation management can strengthen these ecological services.

7.1 Reflections on future research and planning considerations

Future research on SWP performance should prioritize a deeper understanding of biogeochemical processes over time, with particular attention to seasonal variations in nutrient fluxes and internal nutrient cycling. Long-term monitoring is necessary to identify how these processes influence nutrient retention or release under different environmental conditions. Additionally, pilot-scale interventions, such as mesocosm studies, can be valuable tools for testing the effectiveness of nature-based solutions in a controlled yet realistic context.

Exploring the potential for reusing harvested algae, for example in biofuel production or as fertilizer, may also offer promising opportunities to close nutrient loops and increase system sustainability. To guide practical implementation, future studies should incorporate cost-benefit analyses and life-cycle assessments that include both ecological performance and social acceptance. Furthermore, research into how specific plant species affect nutrient uptake and ecosystem resilience could inform better design and retrofitting strategies.

The findings in this thesis point to the need for further research into pond-specific responses to management strategies. For example, the effectiveness of barley straw across different pond conditions remains underexplored. Likewise, questions remain about nutrient contributions from adjacent features like the rain beds, which may influence the high P levels observed.

In planning a new SWP, careful consideration should also be given to their placement, surrounding landscape, intended public use and construction process to guarantee a proper function of the system. Ponds situated in visible or high-traffic areas may benefit from design elements such as partial visual barriers or restricted access to reduce disturbances while enhancing ecological function. Decisions about vegetation, aesthetics, and accessibility should reflect an inclusive, interdisciplinary approach—one that balances the goals of urban recreation, safety, and water quality protection.

7.2 Final remarks

Excessive FA growth in SWP is symptomatic of complex, site-specific interactions between physical design, water chemistry, biological communities, and human management. This thesis reinforces the need for integrative thinking in SWP design and maintenance—where ecological functionality is not an afterthought, but a central component of long-term water quality performance. A transition toward more holistic, adaptive, and ecologically informed management is not only possible but necessary to meet the growing environmental and urban challenges of today's stormwater systems.

8 References

Norconsult Sverige AB (2024). *Slutrapport Gottsunda Dagvattenpark: Kontrollprogram miljö (Uppdragsnr.: 108 55 49 Version: 1),* Stockholm: Norconsult Sverige AB.

Ahmed, S., Loewen, M.R., Zhang, W., Ghobrial, T.R., Zhu, D.Z., Mahmood, K. & van Duin, B. (2022). Field observations of stratification in stormwater wet ponds. *Journal of Environmental Management,* Volym 322, pp.115988–115988.

Al-Mehdawi, H. & Jamalaldin, L. (2014). *Algtillväxten i öppna dagvattenanläggningar (examensarbete).* Malmö högskola https://www.diva-portal.org/smash/get/diva2:1480626/FULLTEXT01.pdf

Andersson, J., Stråe, D., Byström, Y., van der Nat, D. & Granath, M. (2013). *Skötsel av dagvattendammar - en handbook.* WRS Water Revival Systems.

Ask, J. (2010). *Carbon metabolism in clear-water and brown-water lakes,* Umeå: Department of Ecology and Environmental Science, Umeå University.

Ball, A., Williams, M., Vincent, D. & Robinson, J. (2001). Algal growth control by a barley straw extract. *Bioresource Technology,* 77(2), pp. 177-181.

Bjerking AB (2016). *Bygghandling, Fullerö Bostäder. Fjädermolnsvägen. F78-10.*

Bjerking AB (2017a). *Relationshandling, Fullerö Bostäder. Fjädermolnsvägen, F78-03.*

Bjerking AB (2017b). *Relationshandling, Fullerö Bostäder. Fjädermolnsvägen. F78-12.*

Bjerking (2020). *PM Rapport: Elsa Eschelssons park - Utformning av dagvattendamm. Uppdrag nr. 20U1308,* Bjerking AB.

Blecken, G. (2016). *Kunskapssammanställning dagvattenrening,* Svenskt Vatten AB.

Borchardt, M. (1996). 7 - Nutrients. i: R. Stevenson, M. Bothwell & R. Lowe, red. *In Aquatic Ecology, Algal Ecology.* Academic Press, pp. 183-227.

Budweg, E. (2023). *Dagvattendammar som biodiversitet-hotspots? En studie av 19 dammar i Mälardalen,* Biologiska institutionen, Lunds universitet.

https://wrs.se/wp-content/uploads/2024/02/Budweg_Dagvattendammar-som-biodiversitet-hotspots_2024.pdf [2025-03-20]

Burkholder, J. (1996). Interactions of benthic algae with their substrata. i: R. Stevenson, M. Bothwell & R. Lowe, red. *Algal ecology: freshwater benthic ecosystems*. Academic Press, pp. 253-297.

Bydén, S., Larsson, A.-M. & Olsson, M. (2003). *Mäta vatten. Undersökningar av sött och salt vatten*. Tredje upplaga red. Göteborg: Instutionen för miljövetenskap och kulturvård, Göteborgs Universitet.

Caffrey, J. & Monahan, C. (1999). Filamentous algal control using barley straw. *Hydrobiologia,* Volume 415, pp. 315-318.

Carter-Lund, H. & Lund, J. (1995). *Freshwater algae: their microscopic world explored*. Bristol: Biopress Limited.

Charlson, R. J. & Rodhe, H. (1982). Factors controlling the acidity of natural rainwater. *Nature,* 295(5851), pp. 683-685.

Clawson, B. (2016). *Using aquatic dyes in ponds*. [Online] https://www.canr.msu.edu/news/using_aquatic_dyes_in_ponds [2025-03-24]

DeNicola, D. (1996). 6. Periphyton responses to temperature at different ecological levels. i: R. Stevenson, M. Bothwell & R. Lowe, red. *Algal Ecology: freshwater benthic ecosystems*. San Diego: Academic Press, pp. 149 - 181.

Dodds, W. & Gudder, D. (1992). The Ecology of Cladophora. *Journal of Phycology,* 28(4), pp. 415-427.

Ejderby, S. (2023). *Kartläggning och värdering av ekosystemtjänster för två multifunktionella vattenparker*. Institutionen för ekologi och genetik vid Uppsala Universitet. https://www.diva-portal.org/smash/get/diva2:1773261/FULLTEXT01.pdf

Enell, M. & Löfgren, S. (1988). Phosphorus in interstitial water: Methods and dynamics. *Hydrobiologia,* Volume 170, pp. 103-132.

Erickson, A., Weiss, P. & Gulliver, J. (2018). Monitoring and Maintenance of Phosphate Adsorbing Filters. *Journal of Environmental Engineering,* 144(1).

European Environment Agency (2021). *Nature-based solutions in Europe: Policy, knowledge and practice for climate change adaptation and disaster risk reduction,* Copenhagen: European Environment Agency.

European Parliament and Council (2000). Directive 2000/60/EC of October 23, 2000, of the European parliament and of the council establishing a framework for community action in the field of water policy. *OJ L* 327, 22.12.2000, pp. 1–73.

Everall, N. & Lees, D. (1996). The use of barley-straw to control general and blue-green algal growth in a Derbyshire reservoir. *Water Research,* 30(2), pp. 269-276.

Fervier, V., Urrutia-Cordero, P., Piano, E., Bona, F., Persson, K.M. & Hansson, L.-A. (2019). Evaluating Nutrient Reduction, Grazing and Barley Straw as Measures Against Algal Growth. *Wetlands,* 40(1), pp. 193-202.

Florida LAKEWATCH (2000). *A Beginner's Guide to Water Management - Nutrients. Information Circular 102,* Department of Fisheries and Aquatic Sciences, Institute of Food and Agricultural Sciences, University of Florida.

France, R., Howell, E., Paterson, M. & Welbourn, P. M. (1991). Relationship between littoral grazers and metaphytic algae in five softwater lakes. *Hydrobiologia,* Volume 220, pp. 9-27.

Frost, P.C., Prater, C., Scott, A.B., Song, K. & Xenopoulos, M.A. (2019). Mobility and Bioavailability of Sediment Phosphorus in Urban Stormwater Ponds. *Water Resources Research,* 55(5), p. 3680–3688.

Gao, X., Zhang, H, Zhang, J, Weng, N & Huo, S (2025). Inactivation performance, influencing factors, and mechanisms of advanced oxidation processes for the control of toxic algae. *Journal of Water Process Engineering,* Volume 72, p. 107538–107538.

Gerrath, J. (2003). 9 - Conjugating green alage and desmids. i: J. Wehr & R. Sheath, red. *In Aquatic Ecology, Freshwater Algae of North America.* Academic Press, pp. 353-381.

Gibson, M., Welch, I., Barrett, P. & Ridge, I. (1990). Barley straw as an inhibitor of algal growth II: laboratory studies. *Journal of Applied Phycology,* 2(3), pp. 241-248.

Goldsborough, L. & Robinson, G. (1996). Pattern in Wetlands. i: R. Stevenson, M. Bothwell & R. Lowe, red. *Algal Ecology: freshwater benthic ecosystems.* San Diego: Academic Press, pp. 77-117.

Greenfield, D.I., Duquette, A., Goodson, A., Keppler, C.J., Williams, S.H., Brock, L.M., Stackley, K.D., White, D. & Wilde, S.B. (2014). The Effects of Three Chemical Algaecides on Cell Numbers and Toxin Content of the Cyanobacteria

Microcystis aeruginosa and Anabaenopsis sp. *Environmental Management,* 54(5), p. 1110–1120.

Guiry, M. & Guiry, G. (2025). *Algae Base,* World-wide electronic publication: University of Galway. [2025-02-10]

Hall, J. & McCourt, R. (2017). Zygnematophyta. i: J. S. A. S. C. Archibald, red. *Handbook of the Protists*. Springer, p. 135–163.

Hansen, P., Phlips, E. & Aldridge, F. (1997). The Effects of Sediment Resuspension on Phosphorus Available for Algal Growth in a Shallow Subtropical Lake, Lake Okeechobee. *Lake and Reservoir Management,* 13(2), p. 154–159.

Hansson, L. A., Gyllström, M., Ståhl-Delbanco, A. & Svensson, M. (2004). Responses to fish predation and nutrients by plankton at different levels of taxonomic resolution. *Freshwater Biology,* 49(9), pp. 1538-1550.

Hartshorn, N., Marimon, Z., Xuan, Z., Cormier, J., Chang, N.B. & Wanielista, M (2016). Complex interactions among nutrients, chlorophyll-a, and microcystins in three stormwater wet detention basins with floating treatment wetlands. *Chemosphere,* Volume 144, p. 408–419.

Hassall, C. & Anderson, S. (2014). Stormwater ponds can contain comparable biodiversity to unmanaged wetlands in urban areas. *Hydrobiologia,* 745(1), p. 137–149.

Hillebrand, H. (1983). Development and dynamics of floating clusters of filamentous algae. i: R. Wetzel, red. *Periphyton of Freshwater Ecosystems*. The Hague: Dr W. JUNK, pp. 31-39.

Hill, W. (1996). 5 - Effects of Light. i: R. Stevenson, M. Bothwell & R. Lowe, red. *In Aquatic Ecology, Algal Ecology*. Academic Press, pp. 121-148.

John, D. (2003). 8 - Filamentous and plantlike green algae. i: J. Wehr & R. Sheath, red. *Freshwater Algae of North America*. Academic Press , pp. 311-352.

Karavan Landskapsarkitekter (2009). *Bygghandling, Ultuna VA, Ultunaallén. del 3. U10-39*.

Karavan Landskapsarkitekter (2019). *Kalkylhandling. Elsa Eschelssons park Uppsala. Detaljritning 1. Principsektioner för dagvattendamm L-32-6-01,* Karavan landskapsarkitekter AB.

Karavan Landskapsarkitekter (n.d.). *Elsa Eschelssons park*. [Online] https://karavanlandskap.se/elsa-eschelssons-park/[2025-02-19]

Lantmäteriet (n.d.). *Min karta,* https://minkarta.lantmateriet.se/ [2025-02-14]

Liu, J. & Vyverman, W. (2015). Differences in nutrient uptake capacity of the benthic filamentous algae Cladophora sp., Klebsormidium sp. and Pseudanabaena sp. under varying N/P conditions. *Bioresource Technology,* Volume 179, pp. 234-242.

Liu, S., Johnson, F., Tamburic, B., Crosbie, N. D. & Glamore, W. (2021). The Effectiveness of Global Constructed Shallow Waterbody Design Guidelines to Limit Harmful Algal Blooms. *Water Resources Research,* 08.57(8).

Lusk, B. (2023). *Pros and Cons of Pond Dye.* [Online] https://www.bassresource.com/fish_biology/pond-dye.html [2025-03-25]

Lusk, M., Bean, E., Iannone, B. & Reisinger, A. (2025). Stormwater ponds: Unaccounted environmental challenges of a widely-adopted best management practice in urban landscapes. *Journal of Environmental Management,* Volume 374, p. 124170–124170.

Malmö stad (2015). *Västra Hamnen: pågående stadsutveckling,* Malmö: Stadsbyggnadskontoret, Malmö stad.

Manaaki Whenua - Landcare Research (2025). *Freshwater algae.* [Online] https://www.landcareresearch.co.nz/tools-and-resources/identification/freshwater-algae/ [2025-02-12]

McCoy, J., Chaffee, M., Mittelstet, A., Messer, T. & Comfort, S. (2024). Nitrate Removal by Floating Treatment Wetlands under Aerated and Unaerated Conditions: Field and Laboratory Results. *Nitrogen,* Volume 5, p. 808–827.

McEnroe, N. A., Buttle, J. M., Marsalek, J., Pick, F. R., Xenopoulos, M. A. & Frost , P. C. (2013). Thermal and chemical stratification of urban ponds: Are they ‘completely mixed reactors’?. *Urban Ecosystems,* Volume 16, p. 327–339.

Melin, F., Persson, M., Söderquist, J., Nilson, R., Karlsson, I. & Farquharson, L. (n.d.). *Fallstudier inom projektet SODA - Samverkan för ett hållbart omhändertagande av dagvatten på kvartersmark – En sammanställning över projektets fallstudier och referensanläggningar,* https://vaguiden.se/wp-content/uploads/2023/09/SODA--En-sammanstallning-over-projektets-fallstudier-och-referensanlaggningar.pdf: [2025-02-19]

Minelgaite, G., Frost, P.C., Xenopoulos, M.A., Stephansen, D.A., Fejerskov, M.L. & Vollertsen, J. (2020). Planktonic algae abundance and diversity are similar in urban stormwater ponds of different geographic locations and natural shallow lakes. *Urban Ecosystems,* 23(4), p. 841–850.

Minnesota Stormwater Manual (2020). *Iron enhanced sand filter (Minnesota Filter).* [Online] https://stormwater.pca.state.mn.us/index.php/Iron_enhanced_sand_filter_(Minnesota_Filter) [2025-04-23]

Monaghan, P., Hu, S., Hansen, G., Ott, E., Nealis, C. & Morera, M. (2016). Balancing the Ecological Function of Residential Stormwater Ponds with Homeowner Landscaping Practices. *Environmental Management,* 58(5), p. 843–856.

Naturvårdsverket (2021). *Naturbaserade lösningar - ett verktyg för klimatanpassning och andra samhällsutmaningar*. Naturvårdsverket. https://www.naturvardsverket.se/4ac248/globalassets/media/publikationer-pdf/7000/978-91-620-7016-2.pdf [2025-03-31]

Norconsult Sverige AB (2024a). *Slutrapport Gottsunda Dagvattenpark: Kontrollprogram miljö (Uppdragsnr. 108 55 49 Version: 1),* Stockholm: Norconsult Sverige AB.

Norconsult Sverige AB (2024b). *Utformning av dagvattendammar sträcka D (Uppdragsnr. 108 25 76 Version: 6),* Stockholm: Norconsult Sverige AB.

Norconsult Sverige AB (2024c). *Utformning av dagvattendammar sträcka D (Uppdragsnr. 108 25 76-04 Revision: 0.3),* Stockholm: Norconsult AB.

Nyström, P., Svensson, O., Lardner, B., Brönmark, C. & Granéli, W. (2001). The influence of multiple introduced predators on a littoral pond community. *Ecology,* 82(4), p. 1023–1039.

Näslund, J., Andersson, J. & Arnlund, J. (2023). *Pilotstudie – avskiljning av lösta och partikelbundna föroreningar i dagvattendammar*. [Online] https://wrs.se/wp-content/uploads/2023/03/WRS-Pilotstudie-avskiljning-fororeningar-dammar-inkl-bilagor-vers-1_1.pdf [2025-02-17]

Oliver, R. & Walsby, A. (1988). [55] Buoyancy and suspension of planktonic cyanobacteria. i: *Methods in Enzymology*. Volume 167, pp. 521-527.

Park, J., Church, J., Son, Y., Kim, K.-T. & Lee, W.H. (2017). Recent advances in ultrasonic treatment: Challenges and field applications for controlling harmful algal blooms (HABs). *Ultrasonics Sonochemistry,* Volume 38, p. 326–334.

Permbro, M. (2021). Alger i Vikhemsdamm ska bekämpas med kornhalm. *Skånska Dagbladet*, 22 08, pp. https://www.skd.se/2021-08-24/alger-i-vikhemsdamm-ska-bekampas-med-kornhalm/ [2025-05-11]

Persson, J. (2000). The hydraulic performance of ponds of various layouts. *Urban Water,* 2(3), p. 243–250.

Pettersson Skog, A. (2024). *Utredning Regnbäddssubstrat,* Uppsala: RISE Research Institutes of Sweden AB.

Pettersson Skog, A., Johansen, A., Farquharson, L., Stenbeck, S. & Hellman, J. (2023). *Kvalitetskriterier för regnbäddssubstrat,* Uppsala: RISE Research Institutes of Sweden AB.

Planas, D., Lapierre, L., Moreau, G. & Allard, M. (1989). Structural organization and species composition of a lotic periphyton community in response to experimental acidification. *Canadian journal of fisheries and aquatic sciences,* Volume 46, pp. 827-835.

Purcell, D., Parsons, S. & Jefferson, B. (2013). The influence of ultrasound frequency and power, on the algal species Microcystis aeruginosa, Aphanizomenon flos-aquae, Scenedesmus subspicatus and Melosirasp.. *Environmental Technology,* 34(17), p. 2477–2490.

Ridge, I. & Pillinger, J. (1996). Towards understanding the nature of algal inhibitors from barley straw. *Hydrobiologia,* 340(1-3), pp. 301-305.

Ridge, I., Walters, J. & Street, M. (1999). Algal growth control by terrestrial leaf litter: a realistic tool?. *The Ecological Bases for Lake and Reservoir Management,* pp. 173-180.

Segerlind, D. & Östberg, A. (2024). *PM Grodinventering Ultuna 2024,* Sweco. https://www.uppsala.se/contentassets/d83124e5e676471cb6068f12b6ad279d/granskning/u_pm-groddjursinventering-ulltuna-6-juni-2024.pdf [2025-03-18]

SFS 2006:412. *Public Water Services Act (Lag om allmänna vattentjänster).* Stockholm: The Ministry of Climate and Enterprise.

SGU (2023). *Kartvisare Jordarter 1:25000-1:1000000,* https://apps.sgu.se/kartvisare/kartvisare-jordarter-25-100.html [2025-05-11]

Singh, G. & Patidar, S. (2023). Water quality improvement using novel attached growth systems. *Separation Science and Technology,* 58(5), p. 1004–1026.

SLU (2024). *PuddleJump – Förbättrar länken mellan dammar, multifunktion och förvaltning.* [Online] https://www.slu.se/institutioner/vattenmiljo/forskning/forskningsprojekt/alla-forskningsprojekt/gh/puddlejump/ [2025-02-17]

SMHI (n.d.). *Ladda ner meteorologiska observationer*. https://www.smhi.se/data/hitta-data-for-en-plats/ladda-ner-vaderobservationer/ [2025-02-10]

Stahre, P. (2004). *En långsiktigt hållbar dagvattenhantering. Planering och exempel*. Klippan: Svensk Vatten.

Steinman, A. (1996). 12 - Effects of Grazers on Freshwater Benthic Algae. i: R. Stevenson, M. Bothwell & R. Lowe, red. *In Aquatic Ecology, Algal Ecology*. Academic Press, pp. 341-373.

Stenström, Y., Åkerman, S. & Eskilssdotter, S. (2019). *Systemhandling för multifunktionell dagvattenpark i Södra Gottsunda,* Uppsala: WRS AB.

Stephenson, D., ed. (1981). Standard Methods of Design. In: *Developments in Water Science*. Elsevier, pp. 38-54.

Stevenson, R. (1996). 1. Algal Ecology in Freshwater Benthic Habitats. i: R. Stevenson, M. Bothwell & R. Lowe, red. *Algal Ecology: freshwater benthic ecosystems*. San Diego: Academic Press, pp. 3-26.

Stråe, D., van der Nat, D. & Granath, M. (2019). *Uppsala dagvattenplan,* Uppsala: WRS.

Svenda, S. (2024). *Kontinueliga sensormätninger av turbiditet som metod för att kvantifiera transport och avskiljning av föroreningar i dagvatten (masteruppsats),* Uppsala/Visby: Uppsala Universitet.

Søndergaard, M., Jensen, J. & Jeppesen, E. (2003). Role of sediment and internal loading of phosphorus in shallow lakes. *Hydrobiologia,* 506-509(1-3), p. 135–145.

Trochine, C., Guerrieri, M., Liboriussen, L., Meerhoff, M., Lauridsen, T.L., Søndegaard, M. & Jeppesen, E. (2010). Filamentous green algae inhibit phytoplankton with enhanced effects when lakes get warmer. *Freshwater Biology,* 56(3), p. 541–553.

Uppsala kommun (2013). *Bygghandling, Rörby Bälinge, Ekåkersvägen. B163-6*.

Uppsala kommun (2016). *Översiktsplan 2016 för Uppsala kommun*. Uppsala kommun.

https://www.uppsala.se/contentassets/7d682210066f491ba5236651b03f253e/op-2016-del-a-huvudhandling2.pdf [2025-04-07]

Uppsala kommun (2024). *Ändring av detaljplan för Rosendalsfältet, diarienr: PBN 2024-000301. Bilaga 2, Plankarta,* Uppsala: Uppsala kommun.

Uppsala kommun (u.d.a). *Så arbetar vi med: Klimatanpassning,* https://www.uppsala.se/kommun-och-politik/sa-arbetar-vi-med-olika-amnen/sa-arbetar-vi-med-klimatanpassning/ [2025-04-07]

Uppsala kommun (n.d.b). *Uppsala växer,* https://bygg.uppsala.se/samhallsbyggnad-utveckling/uppsala-vaxer/ [2025-04-07]

Uppsala Vatten (2021). *Bygghandling, Brandmästargatan R-51.1-001 Driftläge DAV.*

Uppsala Vatten (2023a). *Skötselplan för dagvattenanläggning. Ekåkersvägen, Rörby/Bälinge (våtdamm),* Uppsala: Uppsala Vatten och Avfall AB.

Uppsala Vatten (2023b). *Skötselplan för dagvattenanläggning. Fjädermolnsvägen, Fullerö (våtdammar),* Uppsala: Uppsala Vatten och Avfall AB.

Uppsala Vatten (2023c). *Skötselplan för dagvattenanläggning Ultunaallén (våtdamm),* Uppsala: Uppsala Vatten och Avfall AB.

Uppsala Vatten (2024). *Uppsalaåsen - grundvatten,* https://www.uppsalavatten.se/om-oss/verksamhet-och-drift/dricksvatten/uppsalaasen---grundvatten [2025-04-07]

Uppsala Vatten (u.d.a). *Dagvattenanläggningen.* [Online] https://www.uppsalavatten.se/om-oss/vara-anlaggningar/dagvattenanlaggningen [2025-02-14]

Uppsala Vatten (u.d.b). *Om oss.* [Online] https://www.uppsalavatten.se/om-oss [2025-02-14]

Uppsala Vatten (n.d). *Rensning av alger i Gottsunda Life IP-dammen 2023-07-10.*

US EPA (2009). *Stormwater Wet Pond and Wetland Management Guidebook.* https://www3.epa.gov/npdes/pubs/pondmgmtguide.pdf: [2025-04-20].

Vadeboncoeur, Y., Lodge, D. & Carpenter, S. (2001). Whole-lake fertilization effects on distribution of primary production between benthic and pelagic habitats. *Ecology,* Volume 82, pp. 1065-1077.

Vadeboncoeur, Y. & Lowe, R. (2024). Chapter 25 - Benthic Algae and Cyanobacteria of the Littoral Zone. I. Jones & J. Smol, red. *Wetzel's Limnology (Fourth Edition).* Academic Press, pp. 817-857. https://www.sciencedirect.com/science/article/pii/B9780128227015000025

WEF (2022). The Importance of Stormwater Control Measure Maintenance. In: *Urban Stormwater Controls Operations and Maintenance, WEF Manual of Practice No. 39*. Water Environment Federation (WEF).

Wei, Y.-X., Yung, Y.-K., Jackson, M. & Sawa, T. (1989). Some Zygnemataceae (Chlorophyta) of Ontario, Canada, including descriptions of two new species. *Canadian Journal of Botany,* Volume 67, pp. 3233-3247.

Welch, I., Barrett, P., Gibson, M. & Ridge, I. (1990). Barley straw as an inhibitor of algal growth I: studies in the Chesterfield Canal. *Journal of Applied Phycology,* 2(3), pp. 231-239.

WRS (2021a). *Relationshandling, Gottsunda Dagvattenpark, Eksätravägen. R-51.1-04.*

WRS (2021b). *Relationshandling, Gottsunda Dagvattenpark, Eksätravägen. R-51.2-01.*

Yang, Y. & Lusk, M. (2018). Nutrients in Urban Stormwater Runoff: Current State of the Science and Potential Mitigation Options. *Current Pollution Reports,* 4(2), p. 112–127.

Ystads Allehanda (2013). *Kornbalar ska hålla alger borta.* [Online] https://www.ystadsallehanda.se/artikel/kornbalar-ska-halla-alger-borta/ [2025-05-11]

Yu, B., Zhang, Y., Wu, H., Yan, W., Meng, Y., Hu, C., Liu, Z., Ding, J. & Zhang, H. (2023). Advanced oxidation processes for synchronizing harmful microcystis blooms control with algal metabolites removal: From the laboratory to practical applications. *The Science of The Total Environment,* Volume 906, p. 167650–167650.

Unpublished sources:

Expert contact A (2024). *Online meeting on 17th of September.* (Project Manager, RISE Research Institutes of Sweden).

Expert contact B (2025). *Meeting on the 5th of March.* (Assessment Engineer, Uppsala Vatten).

Expert contact D (2025). *E-mail conversation 7th of March*. (Water and Wastewater Design Engineer, Täby Municipality).

Expert contact E (2025). *Online meeting on 13th of February*. (Researcher at Swedish University of Agricultural Sciences).

Expert contact L (2025). *E-mail conversation, 9th of May*. (Researcher at SLU).

9 Appendices

Appendix A

Table A- 1: Sampling campaign schedule.

Sampling	Date	Sampled	Weather
Sampling 1	2024-10-08	Surface water and algae	Cloudy, no rain, ~10°C
Sampling 2	2024-10-16	Surface water	Sunny, no rain, ~6°C
Sampling 3	2024-11-11	Surface water	No rain, cloudy, ~4°C
Sampling 4	2024-12-10	Surface water	Sunny, ~−5°C
Sampling 5	2025-01-13	Surface water	Partially cloudy, ~−2°C, ice cover
Sampling 6	2025-02-10	Surface water	Sunny, ~−2°C, ice cover
Sampling 7	2025-03-10	Surface water and algae + extra for chlorophyll	Cloudy, light rain, ~2°C
Sampling 8	2025-03-24	Surface water and algae + extra for chlorophyll	Sunny, ~5°C
Sampling 9	2025-04-09	Surface water + extra for chlorophyll	Sunny and windy (northern wind), ~6°C

Table A- 2: Protocol summary: temperature in-situ

Date	Fullerö N	Fullerö	Bällinge	Gottsun	Ultuna	Rosenda	Ultuna 2	Commentary
2024-10-08	8,5	7,5	8,7	9,4	8,8	9,5		Algal mats in Elsa pond, Fullerö southern pond and some algae in northern pond
2024-10-16	6,4	6,5	6,5	7,1	6,9	7,3		
2024-11-11	5,1	5,9	5,8	5,1	6,1	5,5		Rosendal: observed algae in the bottom
2024-12-10	2,1	2,3	2	2,3	2,1	2,7		
2025-01-13	1	1,2	1,1	0,7	1,4	1,3		Some algae in the centre of the ice in Södra pond
2025-02-10	1,2	0,9	1,9	2,1	2,7	3,5		
2025-03-10	3,7	4,1	4,8	5,7	6	5,1		Dead algae found in Södra Damm. Gottsunda pond 0,96 m depth
2025-03-24	4,7	4,8	5,1	5,3	5,2	5,3	5,9	Abundant brown-coloured algae in Södra pond. Gottsunda algae sampling from the main pond; secchi-depth 0,5 m and pond depth 0,88 m

Appendix B

Table B- 1: Stakeholder consultation - list of contacts

Expert Contact	Affiliation	Discussion topics
Expert contact A	Project Manager, RISE Institute	General information about the project and specific details on stormwater system components, such as rain beds. Communication via email and meetings.
Expert contact B	Assessment Engineer, Uppsala Vatten	Technical and maintenance information regarding the stormwater ponds included in the study. Communication via email and meetings.
Expert contact C	Naturvatten i Roslagen AB	Information on algal species identification. Additional input provided by Hydrophyta Ekologikonsult. Communication via email.
Expert contact D	Water and Wastewater Design Engineer, Täby Municipality	Details on pond maintenance practices in Täby Municipality. Communication via email and meeting.
Expert contact E	Researcher, SLU	Water chemistry data from summer 2024 and photographs from the Puddlejump project. Communication via email and meeting.
Expert contact F	Park Engineer, Uppsala Municipality	Information on maintenance of green spaces and parks in Uppsala, especially in the Rosendal area. Communication via email and online meeting.
Expert contact G	Consultant, WRS	Detailed information about Gottsunda Stormwater Park. Communication via online meeting and email.
Expert contact H	Stormwater Strategist, Tyresö Municipality	General and site-specific information on the construction and maintenance of stormwater ponds. Communication via online meeting and email.
Expert contact I	Technical Manager, Staffanstorp Municipality	Insights on the use of barley straw for algae control in ponds. Communication via email.
Expert contact J	Park Manager, Ystad Municipality	Information on the use of barley straw for managing algae in ponds. Communication via email.
Expert contact K	Landscape Strategist, Hedemora Municipality	Details on barley straw application for algae control, with a case example from Lake Hönsan. Communication via email.
Expert contact L	Researcher, SLU	Information on management practices in the Rosendal area and general insights into the stormwater system and rain beds. Communication via email.

Summaries of discussions with expert contacts

Expert contact B - Summary of the personal communication and online meeting with an assessment engineer at Uppsala Vatten.

Online and personal meetings were held with an assessment engineer at Uppsala Vatten. The purpose of the conversation was to get more detailed information regarding the ponds under this study. In the meetings, Bällinge pond was defined as a reference and the engineer shared observations about the presence of algae, nutrients and fish in the ponds, given the partial results of water quality assessment.

Maintenance of the stormwater ponds, including those included in this study, is intended to be carried out monthly during the warmer period of the year. However, according to the documentation and information exchanged with the engineer, the control last year was conducted only once during the summer.

Regarding the studied ponds, according to the engineer, Bälinge serves as the reference pond, since no algae has been observed there. The Ultuna pond hasn't experienced algal blooms since 2015; however, it is the receptor for Veterinärvägen pond, which has been reported to have developed increasing problems with nuisance algae in recent years. Under the observation of high levels of nutrients in Elsa Eschelssons park pond, elevated nutrient levels suggest the possibility of nutrient leakage from nearby rain beds in the Rosendal area.

Although documented fish presence exists only in the Ultunaallén pond, it is possible that fish are present in other ponds as well, according to the engineer. This is likely due to people introducing fish intentionally for recreational fishing purposes.

Expert contact F - Summary of the personal communication and online meeting with park engineer.

An online meeting was held on the 17th of February with a park engineer affiliated with Uppsala municipality. The purpose of the conversation was to gain a better understanding of the responsibilities and maintenance processes undertaken by the Urban Planning Administration Office for the city's green areas. The engineer also shared information on potential nutrient sources that were suspected to affect the studied ponds, as well as observations regarding algae presence in these water bodies.

According to the expert, Uppsala municipality utilizes a GIS based system to plan the maintenance of various types of green spaces. However, no specific maintenance plans exist for the green areas surrounding the stormwater ponds. The park maintenance unit is responsible for municipally owned urban green areas, while stormwater facilities fall under the responsibility of Uppsala Vatten. The municipality does not perform maintenance within the waterbodies, but only minor tasks such as removing overgrown weeds in the ditches. Lawn mowing is carried out every two, or every three weeks in case of dry conditions. Yet no records are kept regarding the performed maintenance activities.

Regarding the studied ponds, the surrounding areas of Ultunaallén pond are not maintained by the municipality. Elsa Eschelssons Park is currently under a two-year warranty maintenance period, managed by the construction company, and has not yet been intervened by the municipality.

Since nutrient input may originate from fertilization of nearby land or other structures, it is important to understand how this is addressed within the municipality. The engineer indicated that grass lawns generally do not require fertilization, though some is applied to ornamental shrubs during the spring cleaning process. Rain beds typically do not require additional fertilization either, as the initial soil placement contains sufficient nutrients to support newly planted vegetation. Moreover, stormwater passing through the rain beds brings high concentrations of nutrients for plant uptake.

In Gottsunda Dagvattenpark, the pond was constructed on a former cultivated field previously used for growing livestock fodder; however, such fields are typically not fertilized. The adjacent field may occasionally be fertilized by the land's tenant, with no intervention from the municipality.

The park maintenance unit has observed that algae growth tends to occur during warm and calm weather conditions. Although complaints have been received, no formal logs are maintained for public reports. For safety reasons, the park unit recommends the installation of fencing around stormwater ponds.

Expert contact G - Summary of the personal communication and online meeting with consultant from WRS.

The online meeting with the consultant working for the company WRS was held on the 27th of February. The aim of this meeting was to gain relevant and more detailed information about Gottsunda Dagvattenpark, since WRS were one of the consultants that helped to dimension and design the pond. According to the consultant, when Gottsunda Dagvattenpark was constructed, the topsoil was removed based on the assumption that higher nutrient content would be concentrated in the topsoil rather than in the underlying clay layer. However, no analyses were conducted to determine the actual nutrient content, and its potential impact on aquatic ecology has not been assessed.

In response to the question about the specific design of the pond and its function, the consultant specified that the role of pre-sedimenters is primarily to capture coarser materials and facilitate the removal of sediments. It is designed for the excavation to be carried out as needed making it easier and more cost-effective without altering the main pond.

The next question answered by the consultant aimed to reveal overlooked sources of nutrient leakage. As stated by the consultant, the dimensioning of the pond and the pollutant removal efficiency were made using StormTac software, but the actual contributing catchment area is larger and includes green areas along the Gottsunda Gipen. The entire Gottsunda Gipen area—comprising fields extending from the southeast to the northwest between the urbanized sections of Gottsunda—contributes to runoff. Moreover, there are some allotments in this area that may contribute to additional nutrient runoff.

The consultant also pointed out that the fenced animal pasture located to the east of the pond probably does not contribute significantly to nutrient runoff. While sheep previously grazed there, no grazing has occurred in recent years due to disturbances from children in the nearby neighbourhoods. Adding to this, it was also highlighted that the grasslands and fields surrounding the pond are not fertilized; therefore, they are not expected to contribute significant amounts of nutrients to runoff.

Commenting on the appearance of nuisance algae, the consultant mentioned that the extensive algae mats covered the entire pond for two consecutive summers, in 2023 and 2024. This had negatively impacted on macrophytes, as the mats block sunlight and inhibited their growth. Consequently, Uppsala Vatten decided to remove the algae on one occasion. According to the consultant, the ecology of the pond system should be studied to reveal possible triggers and favourable conditions of the macroalgae growth.

Additionally, a design drawing of the Gottsunda Dagvattenpark was obtained through the email conversation with the consultant, along with some contacts.

Expert contact H - Summary of the personal communication and online meeting with stormwater strategist at Tyresö municipality

The meeting with stormwater strategist at Tyresö municipality took place on February 26th, with the purpose of obtaining information about the maintenance and conditions of stormwater ponds in Tyresö municipality to compare with the studied ponds in Uppsala.

According to the stormwater strategist, Tyresö Municipality also experiences issues with FA, though they are not actively removed. This is primarily an aesthetic issue—while some residents express complaints, others are less concerned. Algal blooms are a natural occurrence, and perceptions vary among individuals: for some, algae are a visual nuisance, while others are indifferent.

There are eight stormwater ponds in the municipality and all experience algal growth, but it can occur at different times, though no specific seasonal patterns have been identified. All the ponds are well-established and have mature vegetation. One of them is scheduled for sediment removal, with sediment layers estimated between 90 cm and 1 meter thick. The strategist pointed out that algal mats tend to peak typically in July, coinciding with periods of low inflow. Algae tend to sink or be washed away after rainfall, leading to noticeable decrease in complaints after rainy periods.

As mentioned by the stormwater strategist, Tyresö municipality has commissioned an inventory of macrophytes in the municipality's stormwater ponds. It provided valuable insights into the biodiversity within these ponds. The findings indicate that biodiversity is well-established. However, there may be a discrepancy between expert assessments and public perception, as some residents may see the ponds as poorly maintained. Nevertheless, lush vegetation can play a crucial role in supporting food webs, providing habitat for various organisms and shading water surfaces thereby helping to regulate nuisance algae.

The stormwater strategist discussed that the planning and construction of stormwater systems is a long and complex process involving multiple actors and stakeholders. Over time, modifications may occur due to changes in land use and surrounding conditions, which can lead to deviations from the original design intentions and may impact the pond's performance. For this reason, effective communication is essential for successful stormwater management. Moreover, budget constraints present challenges for inspection and maintenance activities carried out by the responsible authorities. The ability to perform necessary actions also depends on the number of ponds requiring follow-up within the municipality.

The strategist also acknowledged that newly constructed ponds often require more intensive maintenance during their initial years, as biological communities are still developing. The most significant investments in maintenance and monitoring are typically needed during the first five years. Once the vegetation and ecosystem are fully established, maintenance intervals can be extended, ultimately reducing long-term costs.

During the process of personal communication with the stormwater strategist, macrophyte inventory reports and a bachelor’s thesis by Budweg (2023), which studied biodiversity in various stormwater ponds, including one in the Tyresö municipality and Gottsunda Dagvattenpark were obtained.

Appendix C

Table C- 1: Water chemistry analysis methods used at Erken laboratory, Uppsala University.

Parameter	Analys id	Referens	Provtyp (Sample type)	Mätområde (Sample range)	Mätosäkerhet (Uncertainty)
pH	EV 01	SS-EN ISO 10523:2012	1,2,3	pH 3-10 0,1 pH enhet	± 0,3 enh
Konduktivitet (Conductivity)	EV 02	SS EN 27 888 utg 1	1,2,3	1-1000 mS/m	± 6 % vid 7- 145 mS/m
Alkalinitet (Alcalinity)	EV 04	SS EN ISO 9963-2	1,2,3	0,01-4 mekv/l	± 18 % vid 0,10 mekv/l ± 9 % vid 1,00 - 4,00 mekv/l
Turbiditet (Turbidity)	EV 26	ISO 7027-1 :2016	1,2	0,1-200 NTU	± 29 % vid 2,0 NTU ± 27 % vid 4,0-20 NTU
Fosfatfosfor (Phosphate phosphorous PO4-P)	EV 41	Method No G-175-96 Rev. 16 för AA3och SS-EN ISO 6878:2005 samt egen metodik	1,2,3	6-500µg/l	± 32 % vid(5-15 µg/l ± 25 % vid 15-100 µg/l ± 23 % vid 100-500 µg/l
Totalfosfor (Total phosphorous Tot-P)	EV 43	Method No G-297-03 Rev. 7 för AA3 och SS-EN ISO 6878:2005 samt egen metodik	1,2,3	11-1000 µg/l	± 26 % vid 5-15 µg/l ± 18 % vid 15-100 µg/l ± 15 % vid 100-1000 µg/l

Klorofyll a (Chlorophyll a, Chl-a)	EV 18	SS 28146, (1) mod	1,2	> 1µg/l	± 26 % Δ Δ mätning av dubbelprov
Ammoniumkväve (Ammonium nitrogen NH_4-N)	EV 44	Method No G-171-96 Rev 17 för AA3 och SS EN ISO 11732:2005 utg. 1 samt egen metodik	1,2,3	10-500 µg/l	± 30 % vid 5-15 µg/l ± 18 % vid 15-100 µg/l ± 16 % vid 100-500 µg/l
Nitrit+Nitratkväve (Nitrite/nitrate nitrogen NO_2+NO_3-N)	EV 46	Method No G-384-08 Rev. 6 för AA3 och SS-EN ISO 13395 utg. 1 samt egen metodik	1,2,3	7-500 µg/l	± 45 % vid 5-15 µg/l ± 22 % vid 15-100 µg/l ± 19 % vid 100-500 µg/l
Totalkväve (Total nitrogen Tot-N)	EV 48	Method No G-384-08 Rev. 6 och G-172-96 Rev. 19 för AA3 SS-EN ISO 13395 utg. 1 SS-EN ISO 11905-1	1,2,3	125-2000 µg/l	± 25 % vid 100-188 µg/l ± 20 % vid 188-375 µg/l ± 15 % vid 375-2000 µg/l

Provtagning (Sampling method)

Parameter	Referens	Provtyp
Vatten, provtagning	SS-EN ISO 5667-6:2016	1,2

Appendix D

Erkenlaboratoriet
Institutionen för Ekologi och Genetik
Uppsala Universitet

Ackred. nr 1239 Provning ISO/IEC 17025

RAPPORT
Utfärdat av ackrediterat laboratorium
REPORT issued by Accredited Laboratory

Sida
1/2

Projekt	Uppsala dagvattendammar	**Kontakt**	Margarita Judina
Mottagare	Robyn Övergaard	**Uppdragsgivare**	Margarita Judina
Följesedel	24-231		Risslingbyvägen 1
Rapportdatum	2024-12-04 15:54:44		761 74 Norrtälje
Kommentar			Sverige

Provinformation

Analys	Provplats	Provpunkt	Övrigt	Provtagningsdatum	Ankomstdatum	Provtyp
242100	NDAMM	Norra damm		2024-10-08	2024-10-08	Vatten
242101	SDAMM	Södra damm		2024-10-08	2024-10-08	Vatten
242102	BÄLDAMM	Bälinge damm		2024-10-08	2024-10-08	Vatten
242103	GOTDAMM	Gottsunda damm		2024-10-08	2024-10-08	Vatten
242104	ULTUNADAMM	Ultuna damm		2024-10-08	2024-10-08	Vatten
242105	ROSDAMM	Rosendal damm		2024-10-08	2024-10-08	Vatten

Standardanalyser

Analys	Provplats	Provpunkt	Övrigt	pH	Konduktivitet	Turbiditet
ID				EV:1	EV:2	EV:26
Enhet				25°	mS/m	FNU
242100	NDAMM	Norra damm		7.5 ±0.3◇	10.1 ±0.60◇	0.52 ±0.15
242101	SDAMM	Södra damm		7.3 ±0.3◇	22.0 ±1.3◇	0.55 ±0.16
242102	BÄLDAMM	Bälinge damm		7.3 ±0.3◇	2.5 ±0.15	4.5 ±1.2
242103	GOTDAMM	Gottsunda damm		8.3 ±0.3	16.0 ±0.96	14 ±3.8
242104	ULTUNADAMM	Ultuna damm		7.8 ±0.3	19.1 ±1.1	23 ±6.3
242105	ROSDAMM	Rosendal damm		8.1 ±0.3	21.7 ±1.3	1.2 ±0.35

Forforanalyser SEAL

Analys	Provplats	Provpunkt	Övrigt	Fosfatfosfor	Totalfosfor
ID				EV:41	EV:43
Enhet				µg/l	µg/l
242100	NDAMM	Norra damm		<2◇	10!
242101	SDAMM	Södra damm		2!◇	10!
242102	BÄLDAMM	Bälinge damm		<2◇	40 ±7.3
242103	GOTDAMM	Gottsunda damm		6!◇	34 ±6.1
242104	ULTUNADAMM	Ultuna damm		15 ±3.8◇	87 ±16
242105	ROSDAMM	Rosendal damm		25 ±6.3◇	46 ±8.2

Resultaten gäller för proven såsom de har mottagits.
* Ej ackrediterad analys. ! Mätvärdesspår. ◇ Analys utförd senare än metodregler. Se bilaga 3 för metodförteckning.
Den angivna osäkerheten är en utvidgad mätosäkerhet beräknad med en täckningsfaktor k=2.
Denna rapport får endast återges i sin helhet, om inte Erkenlaboratoriet i förväg skriftligen godkänt annat.

Postadress
Norra Malmavägen 45
761 73 Norrtälje

Telefon
018/471 28 57
018/471 28 58

Org.nr
202100-2932

Signatur
Helena Enderskog

Projekt Uppsala dagvattendammar
Mottagare Robyn Övergaard
Följesedel 24-231
Rapportdatum 2024-12-04 15:54:44
Kommentar

Kontakt Margarita Judina
Uppdragsgivare Margarita Judina
Risslingbyvägen 1
761 74 Norrtälje
Sverige

Kväveanalyser SEAL

Analys	Provplats	Provpunkt	Övrigt	Ammoniumkväve	Nitrat+Nitritkväve	Totalkväve
ID				EV:44	EV:46	EV:48
Enhet				µg/l	µg/l	µg/l
242100	NDAMM	Norra damm		12 ±3.6◇	11 ±4.8◇	240 ±49
242101	SDAMM	Södra damm		95 ±17◇	95 ±21◇	490 ±73
242102	BÄLDAMM	Bälinge damm		<4◇	<4◇	640 ±96
242103	GOTDAMM	Gottsunda damm		5!◇	<4◇	300 ±61
242104	ULTUNADAMM	Ultuna damm		55 ±9.9◇	480 ±90◇	1400 ±200
242105	ROSDAMM	Rosendal damm		9!◇	23 ±5.0◇	630 ±95

Resultaten gäller för proven såsom de har mottagits.
* Ej ackrediterad analys. ! Mätvärdesspår. ◇ Analys utförd senare än metodregler. Se bilaga 3 för metodförteckning.
Den angivna osäkerheten är en utvidgad mätosäkerhet beräknad med en täckningsfaktor k=2.
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761 73 Norrtälje

Telefon
018/471 28 57
018/471 28 58

Org.nr
202100-2932

Signatur
Helena Enderskog

Erkenlaboratoriet
Institutionen för Ekologi och Genetik
Uppsala Universitet

Ackred. nr 1239 Provning ISO/IEC 17025

RAPPORT
Utfärdat av ackrediterat laboratorium
REPORT issued by Accredited Laboratory

Projekt	Uppsala dagvattendammar	**Kontakt**	Margarita Judina
Mottagare	Erika Bridell	**Uppdragsgivare**	Margarita Judina Risslingbyvägen 1 761 74 Norrtälje Sverige
Följesedel	24-240		
Rapportdatum	2024-12-04 16:09:17		
Kommentar			

Provinformation

Analys	Provplats	Provpunkt	Övrigt	Provtagningsdatum	Ankomstdatum	Provtyp
242167	NDAMM	Norra damm		2024-10-16	2024-10-16	Vatten
242168	SDAMM	Södra damm		2024-10-16	2024-10-16	Vatten
242169	BÄLDAMM	Bälinge damm		2024-10-16	2024-10-16	Vatten
242170	GOTDAMM	Gottsunda damm		2024-10-16	2024-10-16	Vatten
242171	ULTUNADAMM	Ultuna damm		2024-10-16	2024-10-16	Vatten
242172	ROSDAMM	Rosendal damm		2024-10-16	2024-10-16	Vatten

Standardanalyser

Analys	Provplats	Provpunkt	Övrigt	pH	Konduktivitet	Turbiditet
ID				EV:1	EV:2	EV:26
Enhet				25°	mS/m	FNU
242167	NDAMM	Norra damm		7.4 ±0.3	27.4 ±1.6	1.5 ±0.43
242168	SDAMM	Södra damm		7.4 ±0.3	20.2 ±1.2	3.3 ±0.88
242169	BÄLDAMM	Bälinge damm		6.9 ±0.3	23.3 ±1.4	3.4 ±0.90
242170	GOTDAMM	Gottsunda damm		7.5 ±0.3	17.9 ±1.1	26 ±6.9
242171	ULTUNADAMM	Ultuna damm		7.5 ±0.3	26.5 ±1.6	27 ±7.3
242172	ROSDAMM	Rosendal damm		7.7 ±0.3	14.2 ±0.85	5.3 ±1.4

Forforanalyser SEAL

Analys	Provplats	Provpunkt	Övrigt	Fosfatfosfor	Totalfosfor
ID				EV:41	EV:43
Enhet				µg/l	µg/l
242167	NDAMM	Norra damm		<2⋄	12 ±3.0
242168	SDAMM	Södra damm		5!⋄	19 ±3.4
242169	BÄLDAMM	Bälinge damm		<2⋄	30 ±5.4
242170	GOTDAMM	Gottsunda damm		15 ±3.9⋄	52 ±9.3
242171	ULTUNADAMM	Ultuna damm		47 ±12⋄	90 ±16
242172	ROSDAMM	Rosendal damm		310 ±71⋄	330 ±50

Resultaten gäller för proven såsom de har mottagits.
∗ Ej ackrediterad analys. ! Mätvärdesspår. ⋄ Analys utförd senare än metodregler. Se bilaga 3 för metodförteckning.
Den angivna osäkerheten är en utvidgad mätosäkerhet beräknad med en täckningsfaktor k=2.
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Mottagare	Erika Bridell	**Uppdragsgivare**	Margarita Judina Risslingbyvägen 1 761 74 Norrtälje Sverige
Följesedel	24-240		
Rapportdatum	2024-12-04 16:09:17		
Kommentar			

Kväveanalyser SEAL

Analys	Provplats	Provpunkt	Övrigt	Ammoniumkväve	Nitrat+Nitritkväve	Totalkväve
ID				EV:44	EV:46	EV:48
Enhet				µg/l	µg/l	µg/l
242167	NDAMM	Norra damm		33 ±5.9◇	770 ±150◇	1200 ±190
242168	SDAMM	Södra damm		79 ±14◇	170 ±32◇	640 ±96
242169	BÄLDAMM	Bälinge damm		5!◇	53 ±12◇	460 ±69
242170	GOTDAMM	Gottsunda damm		8!◇	360 ±69◇	730 ±110
242171	ULTUNADAMM	Ultuna damm		130 ±20◇	680 ±130◇	1300 ±190
242172	ROSDAMM	Rosendal damm		12 ±3.7◇	31 ±6.8◇	510 ±76

Resultaten gäller för proven såsom de har mottagits.
∗ Ej ackrediterad analys. ! Mätvärdesspår. ◇ Analys utförd senare än metodregler. Se bilaga 3 för metodförteckning.
Den angivna osäkerheten är en utvidgad mätosäkerhet beräknad med en täckningsfaktor k=2.
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Utfärdat av ackrediterat laboratorium
REPORT issued by Accredited Laboratory

Projekt	Uppsala dagvattendammar
Mottagare	Erika Bridell
Följesedel	24-252
Rapportdatum	2024-12-04 16:14:07
Kommentar	

Kontakt	Margarita Judina
Uppdragsgivare	Margarita Judina Risslingbyvägen 1 761 74 Norrtälje Sverige

Provinformation

Analys	Provplats	Provpunkt	Övrigt	Provtagningsdatum	Ankomstdatum	Provtyp
242383	NDAMM	Norra damm		2024-11-11	2024-11-11	Vatten
242384	SDAMM	Södra damm		2024-11-11	2024-11-11	Vatten
242385	BÄLDAMM	Bälinge damm		2024-11-11	2024-11-11	Vatten
242386	GOTDAMM	Gottsunda damm		2024-11-11	2024-11-11	Vatten
242387	ULTUNADAMM	Ultuna damm		2024-11-11	2024-11-11	Vatten
242388	ROSDAMM	Rosendal damm		2024-11-11	2024-11-11	Vatten

Standardanalyser

Analys	Provplats	Provpunkt	Övrigt	pH	Konduktivitet	Turbiditet
ID				EV:1	EV:2	EV:26
Enhet				25°	mS/m	FNU
242383	NDAMM	Norra damm		7.8 ±0.3◇	16.3 ±0.98	5.1 ±1.4
242384	SDAMM	Södra damm		7.5 ±0.3◇	13.4 ±0.81	6.5 ±1.8
242385	BÄLDAMM	Bälinge damm		7.2 ±0.3◇	4.5 ±0.27	4.7 ±1.3
242386	GOTDAMM	Gottsunda damm		8.2 ±0.3◇	28.2 ±1.7	12 ±3.3
242387	ULTUNADAMM	Ultuna damm		7.9 ±0.3	28.3 ±1.7	12 ±3.1
242388	ROSDAMM	Rosendal damm		8.2 ±0.3	17.5 ±1.0	3.4 ±0.92

Forforanalyser SEAL

Analys	Provplats	Provpunkt	Övrigt	Fosfatfosfor	Totalfosfor
ID				EV:41	EV:43
Enhet				µg/l	µg/l
242383	NDAMM	Norra damm		2!◇	23 ±4.2◇
242384	SDAMM	Södra damm		3!◇	24 ±4.3◇
242385	BÄLDAMM	Bälinge damm		4!◇	32 ±5.7◇
242386	GOTDAMM	Gottsunda damm		10 ±3.2◇	73 ±13◇
242387	ULTUNADAMM	Ultuna damm		22 ±5.5◇	98 ±18◇
242388	ROSDAMM	Rosendal damm		160 ±36◇	210 ±31◇

Resultaten gäller för proven såsom de har mottagits.
* Ej ackrediterad analys. ! Mätvärdesspår. ◇ Analys utförd senare än metodregler. Se bilaga 3 för metodförteckning.
Den angivna osäkerheten är en utvidgad mätosäkerhet beräknad med en täckningsfaktor k=2.
Denna rapport får endast återges i sin helhet, om inte Erkenlaboratoriet i förväg skriftligen godkänt annat.

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Projekt	Uppsala dagvattendammar	**Kontakt**	Margarita Judina
Mottagare	Erika Bridell	**Uppdragsgivare**	Margarita Judina Risslingbyvägen 1 761 74 Norrtälje Sverige
Följesedel	24-252		
Rapportdatum	2024-12-04 16:14:07		
Kommentar			

Kväveanalyser SEAL

Analys	Provplats	Provpunkt	Övrigt	Ammoniumkväve	Nitrat+Nitritkväve	Totalkväve
ID				EV:44	EV:46	EV:48
Enhet				µg/l	µg/l	µg/l
242383	NDAMM	Norra damm		17 ±3.0⋄	110 ±21⋄	520 ±78⋄
242384	SDAMM	Södra damm		87 ±16⋄	310 ±59⋄	730 ±110⋄
242385	BÄLDAMM	Bälinge damm		42 ±7.6⋄	180 ±35⋄	660 ±99⋄
242386	GOTDAMM	Gottsunda damm		5!⋄	<4⋄	560 ±84⋄
242387	ULTUNADAMM	Ultuna damm		40 ±7.2⋄	670 ±130⋄	1400 ±200⋄
242388	ROSDAMM	Rosendal damm		7!⋄	8 ±3.6⋄	650 ±98⋄

Resultaten gäller för proven såsom de har mottagits.
⋆ Ej ackrediterad analys. ! Mätvärdesspår. ⋄ Analys utförd senare än metodregler. Se bilaga 3 för metodförteckning.
Den angivna osäkerheten är en utvidgad mätosäkerhet beräknad med en täckningsfaktor k=2.
Denna rapport får endast återges i sin helhet, om inte Erkenlaboratoriet i förväg skriftligen godkänt annat.

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Norra Malmavägen 45
761 73 Norrtälje

Telefon
018/471 28 57
018/471 28 58

Org.nr
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Signatur
Helena Enderskog

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RAPPORT

Utfärdat av ackrediterat laboratorium
REPORT issued by Accredited Laboratory

Projekt	Uppsala dagvattendammar	**Kontakt**	Margarita Judina
Mottagare	Robyn Övergaard	**Uppdragsgivare**	Margarita Judina Risslingbyvägen 1 761 74 Norrtälje Sverige
Följesedel	24-272		
Rapportdatum	2024-12-13 14:22:19		
Kommentar			

Provinformation

Analys	Provplats	Provpunkt	Övrigt	Provtagningsdatum	Ankomstdatum	Provtyp
242549	NDAMM	Norra damm		2024-12-10	2024-12-10	Övrigt
242550	SDAMM	Södra damm		2024-12-10	2024-12-10	Övrigt
242551	BÄLDAMM	Bälinge damm		2024-12-10	2024-12-10	Övrigt
242552	GOTDAMM	Gottsunda damm		2024-12-10	2024-12-10	Övrigt
242553	ULTUNADAMM	Ultuna damm		2024-12-10	2024-12-10	Övrigt
242554	ROSDAMM	Rosendal damm		2024-12-10	2024-12-10	Övrigt

Standardanalyser

Analys	Provplats	Provpunkt	Övrigt	pH	Konduktivitet	Turbiditet
ID				EV:1	EV:2	EV:26
Enhet				25°	mS/m	FNU
242549	NDAMM	Norra damm		7.5 ±0.3	15.6 ±0.94	11 ±3.0◇
242550	SDAMM	Södra damm		7.4 ±0.3	26.6 ±1.6	7.1 ±1.9◇
242551	BÄLDAMM	Bälinge damm		7.0 ±0.3	4.0 ±0.24	6.4 ±1.7◇
242552	GOTDAMM	Gottsunda damm		7.9 ±0.3	35.7 ±2.1	23 ±6.2◇
242553	ULTUNADAMM	Ultuna damm		7.8 ±0.3	40.6 ±2.4	16 ±4.3◇
242554	ROSDAMM	Rosendal damm		7.6 ±0.3	18.7 ±1.1	12 ±3.3◇

Forforanalyser SEAL

Analys	Provplats	Provpunkt	Övrigt	Fosfatfosfor	Totalfosfor
ID				EV:41	EV:43
Enhet				μg/l	μg/l
242549	NDAMM	Norra damm		5!	27 ±4.8
242550	SDAMM	Södra damm		12 ±4.0	33 ±6.0
242551	BÄLDAMM	Bälinge damm		<2	21 ±3.8
242552	GOTDAMM	Gottsunda damm		26 ±6.4	67 ±12
242553	ULTUNADAMM	Ultuna damm		63 ±16	89 ±16
242554	ROSDAMM	Rosendal damm		310 ±71	330 ±50

Resultaten gäller för proven såsom de har mottagits.
⁎ Ej ackrediterad analys. ! Mätvärdesspår. ◇ Analys utförd senare än metodregler. Se bilaga 3 för metodförteckning.
Den angivna osäkerheten är en utvidgad mätosäkerhet beräknad med en täckningsfaktor k=2.
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Projekt	Uppsala dagvattendammar	**Kontakt**	Margarita Judina
Mottagare	Robyn Övergaard	**Uppdragsgivare**	Margarita Judina Risslingbyvägen 1 761 74 Norrtälje Sverige
Följesedel	24-272		
Rapportdatum	2024-12-13 14:22:19		
Kommentar			

Kväveanalyser SEAL

Analys	Provplats	Provpunkt	Övrigt	Ammoniumkväve	Nitrat+Nitritkväve	Totalkväve
ID				EV:44	EV:46	EV:48
Enhet				µg/l	µg/l	µg/l
242549	NDAMM	Norra damm		40 ±7.3	240 ±46	660 ±99
242550	SDAMM	Södra damm		150 ±23	210 ±39	830 ±130
242551	BÄLDAMM	Bälinge damm		6!	100 ±20	280 ±57
242552	GOTDAMM	Gottsunda damm		15 ±4.4	700 ±130	1200 ±170
242553	ULTUNADAMM	Ultuna damm		2800 ±440	910 ±170	4400 ±670
242554	ROSDAMM	Rosendal damm		35 ±6.3	110 ±21	650 ±97

Resultaten gäller för proven såsom de har mottagits.
* Ej ackrediterad analys. ! Mätvärdesspår. ◇ Analys utförd senare än metodregler. Se bilaga 3 för metodförteckning.
Den angivna osäkerheten är en utvidgad mätosäkerhet beräknad med en täckningsfaktor k=2.

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RAPPORT

Utfärdat av ackrediterat laboratorium
REPORT issued by Accredited Laboratory

Projekt	Uppsala dagvattendammar
Mottagare	Robyn Övergaard
Följesedel	25-02
Rapportdatum	2025-05-16 14:50:35
Kommentar	TN EV57 är felaktigt markerad med över tidsgräns och ej ackrediterad. Analysen är ackrediterad.

Kontakt	Margarita Judina
Uppdragsgivare	Margarita Judina Risslingbyvägen 1 761 74 Norrtälje Sverige

Provinformation

Analys	Provplats	Provpunkt	Övrigt	Provtagningsdatum	Ankomstdatum	Provtyp
250011	NDAMM	Norra damm		2025-01-13	2025-01-13	Vatten
250012	SDAMM	Södra damm		2025-01-13	2025-01-13	Vatten
250013	BÄLDAMM	Bälinge damm		2025-01-13	2025-01-13	Vatten
250014	GOTDAMM	Gottsunda damm		2025-01-13	2025-01-13	Vatten
250015	ULTUNADAMM	Ultuna damm		2025-01-13	2025-01-13	Vatten
250016	ROSDAMM	Rosendal damm		2025-01-13	2025-01-13	Vatten

Standardanalyser

Analys	Provplats	Provpunkt	Övrigt	pH	Konduktivitet	Alkalinitet	Turbiditet
Id				EV:1	EV:2	EV:4	EV:26
Enhet				25°	mS/m	mekv/l	FNU
250011	NDAMM	Norra damm		7.0 ±0.3	16.1 ±0.97	1.0 ±0.094⋄	11 ±2.9
250012	SDAMM	Södra damm		7.3 ±0.3	37.4 ±2.2	3.0 ±0.27⋄	9.8 ±2.6
250013	BÄLDAMM	Bälinge damm		6.7 ±0.3	7.3 ±0.44	0.25 ±0.045⋄	7.4 ±2.0
250014	GOTDAMM	Gottsunda damm		7.7 ±0.3	51.3 ±3.1	3.6 ±0.32⋄	8.6 ±2.3
250015	ULTUNADAMM	Ultuna damm		7.5 ±0.3⋄	63.2 ±3.8	4.5 ±0.40⋄	9.1 ±2.5
250016	ROSDAMM	Rosendal damm		7.1 ±0.3⋄	27.7 ±1.7	1.3 ±0.11⋄	8.1 ±2.0

Fosforanalyser SEAL

Analys	Provplats	Provpunkt	Övrigt	Fosfatfosfor	Totalfosfor
Id				EV:41	EV:43
Enhet				µg/l	µg/l
250011	NDAMM	Norra damm		7 ±2.3⋄	26 ±4.8⋄
250012	SDAMM	Södra damm		6!⋄	37 ±6.6⋄
250013	BÄLDAMM	Bälinge damm		<2⋄	24 ±4.3⋄
250014	GOTDAMM	Gottsunda damm		42 ±11⋄	65 ±12⋄
250015	ULTUNADAMM	Ultuna damm		48 ±12⋄	71 ±13⋄
250016	ROSDAMM	Rosendal damm		260 ±61⋄	310 ±50⋄

Resultaten gäller för proven såsom de har mottagits.
* Ej ackrediterad analys. ! Mätvärdesspår. ⋄ Analys utförd senare än metodregler. Se bilaga 3 för metodförteckning.
Den angivna osäkerheten är en utvidgad mätosäkerhet beräknad med en täckningsfaktor k=2.
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REPORT issued by Accredited Laboratory

Projekt	Uppsala dagvattendammar	**Kontakt**	Margarita Judina
Mottagare	Robyn Övergaard	**Uppdragsgivare**	Margarita Judina Risslingbyvägen 1 761 74 Norrtälje Sverige
Följesedel	25-02		
Rapportdatum	2025-05-16 14:50:35		
Kommentar	TN EV57 är felaktigt markerad med över tidsgräns och ej ackrediterad. Analysen är ackrediterad.		

Kväveanalyser SEAL / Shimadzu

Analys	Provplats	Provpunkt	Övrigt	Ammoniumkväve	Nitrat+Nitritkväve	Totalkväve Shimadzu
Id				EV:44	EV:46	EV:57
Enhet				μg/l	μg/l	μg/l
250011	NDAMM	Norra damm		62 ±11◇	140 ±27◇	480 ±72◇
250012	SDAMM	Södra damm		220 ±35◇	190 ±36◇	920 ±140◇
250013	BÄLDAMM	Bälinge damm		5!◇	140 ±27◇	340 ±52◇
250014	GOTDAMM	Gottsunda damm		75 ±14◇	870 ±160◇	1100 ±160◇
250015	ULTUNADAMM	Ultuna damm		120 ±19◇	940 ±180◇	1100 ±170◇
250016	ROSDAMM	Rosendal damm		27 ±4.8◇	84 ±19◇	510 ±76◇

Resultaten gäller för proven såsom de har mottagits.
∗ Ej ackrediterad analys. ! Mätvärdesspår. ◇ Analys utförd senare än metodregler. Se bilaga 3 för metodförteckning.
Den angivna osäkerheten är en utvidgad mätosäkerhet beräknad med en täckningsfaktor k=2.
Denna rapport får endast återges i sin helhet, om inte Erkenlaboratoriet i förväg skriftligen godkänt annat.

Postadress	**Telefon**	**Org.nr**	**Signatur**
Norra Malmavägen 45 761 73 Norrtälje	018/471 28 57 018/471 28 58	202100-2932	Helena Enderskog

Erkenlaboratoriet
Institutionen för Ekologi och Genetik
Uppsala Universitet

Ackred. nr 1239 Provning ISO/IEC 17025

RAPPORT

Utfärdat av ackrediterat laboratorium
REPORT issued by Accredited Laboratory

Projekt	Uppsala dagvattendammar	**Kontakt**	Margarita Judina
Mottagare	Erika Bridell	**Uppdragsgivare**	Margarita Judina Risslingbyvägen 1 761 74 Norrtälje Sverige
Följesedel	25-17		
Rapportdatum	2025-05-16 14:53:56		
Kommentar			

Provinformation

Analys	Provplats	Provpunkt	Övrigt	Provtagningsdatum	Ankomstdatum	Provtyp
250094	NDAMM	Norra damm		2025-02-10	2025-02-10	Vatten
250095	SDAMM	Södra damm		2025-02-10	2025-02-10	Vatten
250096	BÄLDAMM	Bälinge damm		2025-02-10	2025-02-10	Vatten
250097	GOTDAMM	Gottsunda damm		2025-02-10	2025-02-10	Vatten
250098	ULTUNADAMM	Ultuna damm		2025-02-10	2025-02-10	Vatten
250099	ROSDAMM	Rosendal damm		2025-02-10	2025-02-10	Vatten

Standardanalyser

Analys	Provplats	Provpunkt	Övrigt	pH	Konduktivitet	Alkalinitet	Turbiditet
Id				EV:1	EV:2	EV:4	EV:26
Enhet				25°	mS/m	mekv/l	FNU
250094	NDAMM	Norra damm		7.3 ±0.3⋄	27.4 ±1.6⋄	1.8 ±0.16⋄	18 ±4.5
250095	SDAMM	Södra damm		7.4 ±0.3⋄	47.0 ±2.8⋄	3.4 ±0.31⋄	13 ±3.2
250096	BÄLDAMM	Bälinge damm		7.1 ±0.3⋄	5.3 ±0.32⋄	0.29 ±0.052⋄	8.0 ±2.0
250097	GOTDAMM	Gottsunda damm		7.8 ±0.3	54.7 ±3.3	3.9 ±0.35	18 ±4.4
250098	ULTUNADAMM	Ultuna damm		7.5 ±0.3	48.9 ±2.9	3.6 ±0.33	17 ±4.1
250099	ROSDAMM	Rosendal damm		7.7 ±0.3⋄	20.9 ±1.3	0.96 ±0.087	20 ±5.0

Fosforanalyser SEAL

Analys	Provplats	Provpunkt	Övrigt	Fosfatfosfor	Totalfosfor
Id				EV:41	EV:43
Enhet				µg/l	µg/l
250094	NDAMM	Norra damm		5!⋄	28 ±5.1⋄
250095	SDAMM	Södra damm		4!⋄	31 ±5.5⋄
250096	BÄLDAMM	Bälinge damm		<2⋄	11!⋄
250097	GOTDAMM	Gottsunda damm		23 ±5.7⋄	47 ±8.4
250098	ULTUNADAMM	Ultuna damm		5!⋄	63 ±11⋄
250099	ROSDAMM	Rosendal damm		310 ±72⋄	420 ±67⋄

Resultaten gäller för proven såsom de har mottagits.
* Ej ackrediterad analys. ! Mätvärdesspår. ⋄ Analys utförd senare än metodregler. Se bilaga 3 för metodförteckning.
Den angivna osäkerheten är en utvidgad mätosäkerhet beräknad med en täckningsfaktor k=2.
Denna rapport får endast återges i sin helhet, om inte Erkenlaboratoriet i förväg skriftligen godkänt annat.

Postadress
Norra Malmavägen 45
761 73 Norrtälje

Telefon
018/471 28 57
018/471 28 58

Org.nr
202100-2932

Signatur
Helena Enderskog

Erkenlaboratoriet
Institutionen för Ekologi och Genetik
Uppsala Universitet

Ackred. nr 1239
Provning
ISO/IEC 17025

RAPPORT

Utfärdat av ackrediterat laboratorium
REPORT issued by Accredited Laboratory

Projekt	Uppsala dagvattendammar	**Kontakt**	Margarita Judina
Mottagare	Erika Bridell	**Uppdragsgivare**	Margarita Judina Risslingbyvägen 1 761 74 Norrtälje Sverige
Följesedel	25-17		
Rapportdatum	2025-05-16 14:53:56		
Kommentar			

Kväveanalyser SEAL / Shimadzu

Analys	Provplats	Provpunkt	Övrigt	Ammoniumkväve	Nitrat+Nitritkväve	Totalkväve Shimadzu
Id				EV:44	EV:46	EV:57
Enhet				μg/l	μg/l	μg/l
250094	NDAMM	Norra damm		32 ±5.7◇	300 ±56◇	830 ±120
250095	SDAMM	Södra damm		70 ±13◇	280 ±54◇	1000 ±150
250096	BÄLDAMM	Bälinge damm		7!◇	200 ±38◇	310 ±46
250097	GOTDAMM	Gottsunda damm		4!◇	1000 ±190◇	1500 ±230
250098	ULTUNADAMM	Ultuna damm		<4◇	540 ±100◇	1000 ±150
250099	ROSDAMM	Rosendal damm		4!◇	<4◇	910 ±140

Resultaten gäller för proven såsom de har mottagits.
* Ej ackrediterad analys. ! Mätvärdesspår. ◇ Analys utförd senare än metodregler. Se bilaga 3 för metodförteckning.
Den angivna osäkerheten är en utvidgad mätosäkerhet beräknad med en täckningsfaktor k=2.
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RAPPORT
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REPORT issued by Accredited Laboratory

Projekt	Uppsala dagvattendammar	**Kontakt**	Margarita Judina
Mottagare	Helena Enderskog	**Uppdragsgivare**	Margarita Judina
Följesedel	25-51		Risslingbyvägen 1
Rapportdatum	2025-05-16 14:57:06		761 74 Norrtälje
Kommentar			Sverige

Provinformation

Analys	Provplats	Provpunkt	Övrigt	Provtagningsdatum	Ankomstdatum	Provtyp
250281	NDAMM	Norra damm		2025-03-10	2025-03-10	Vatten
250282	SDAMM	Södra damm		2025-03-10	2025-03-10	Vatten
250283	BÄLDAMM	Bälinge damm		2025-03-10	2025-03-10	Vatten
250284	GOTDAMM	Gottsunda damm		2025-03-10	2025-03-10	Vatten
250285	ULTUNADAMM	Ultuna damm		2025-03-10	2025-03-10	Vatten
250286	ROSDAMM	Rosendal damm		2025-03-10	2025-03-10	Vatten

Standardanalyser

Analys	Provplats	Provpunkt	Övrigt	pH	Konduktivitet	Alkalinitet	Turbiditet
Id				EV:1	EV:2	EV:4	EV:26
Enhet				25°	mS/m	mekv/l	FNU
250281	NDAMM	Norra damm		7.4 ±0.3◇	12.1 ±0.73	0.82 ±0.074◇	5.3 ±1.3
250282	SDAMM	Södra damm		7.5 ±0.3◇	33.3 ±2.0	2.6 ±0.23◇	3.8 ±0.96
250283	BÄLDAMM	Bälinge damm		6.9 ±0.3◇	8.1 ±0.49	0.18 ±0.033	9.7 ±2.4
250284	GOTDAMM	Gottsunda damm		8.2 ±0.3◇	52.7 ±3.2	3.9 ±0.36	12 ±3.1
250285	ULTUNADAMM	Ultuna damm		8.0 ±0.3	60.6 ±3.6	4.2 ±0.38	22 ±5.5
250286	ROSDAMM	Rosendal damm		7.5 ±0.3	26.1 ±1.6	1.2 ±0.11	7.4 ±1.8

Fosforanalyser SEAL

Analys	Provplats	Provpunkt	Övrigt	Fosfatfosfor	Totalfosfor
Id				EV:41	EV:43
Enhet				µg/l	µg/l
250281	NDAMM	Norra damm		3!◇	19 ±3.4
250282	SDAMM	Södra damm		2!◇	21 ±3.7
250283	BÄLDAMM	Bälinge damm		3!◇	17 ±3.1
250284	GOTDAMM	Gottsunda damm		29 ±7.3◇	60 ±11
250285	ULTUNADAMM	Ultuna damm		16 ±4.0◇	91 ±16
250286	ROSDAMM	Rosendal damm		150 ±35◇	240 ±39

Resultaten gäller för proven såsom de har mottagits.
* Ej ackrediterad analys. ! Mätvärdesspår. ◇ Analys utförd senare än metodregler. Se bilaga 3 för metodförteckning.
Den angivna osäkerheten är en utvidgad mätosäkerhet beräknad med en täckningsfaktor k=2.
Denna rapport får endast återges i sin helhet, om inte Erkenlaboratoriet i förväg skriftligen godkänt annat.

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Norra Malmavägen 45
761 73 Norrtälje

Telefon
018/471 28 57
018/471 28 58

Org.nr
202100-2932

Signatur
Helena Enderskog

Erkenlaboratoriet
Institutionen för Ekologi och Genetik
Uppsala Universitet

SWEDAC ACKREDITERING
Ackred. nr 1239
Provning
ISO/IEC 17025

RAPPORT

Utfärdat av ackrediterat laboratorium
REPORT issued by Accredited Laboratory

Projekt	Uppsala dagvattendammar	**Kontakt**	Margarita Judina
Mottagare	Helena Enderskog	**Uppdragsgivare**	Margarita Judina
Följesedel	25-51		Risslingbyvägen 1
Rapportdatum	2025-05-16 14:57:06		761 74 Norrtälje
Kommentar			Sverige

Kväveanalyser SEAL / Shimadzu

Analys	Provplats	Provpunkt	Övrigt	Ammoniumkväve	Nitrat+Nitritkväve	Totalkväve Shimadzu
Id				EV:44	EV:46	EV:57
Enhet				µg/l	µg/l	µg/l
250281	NDAMM	Norra damm		5!◇	12 ±5.3◇	290 ±43
250282	SDAMM	Södra damm		18 ±3.3◇	70 ±15◇	510 ±77
250283	BÄLDAMM	Bälinge damm		<4◇	64 ±14◇	270 ±41
250284	GOTDAMM	Gottsunda damm		<4◇	430 ±82◇	820 ±120
250285	ULTUNADAMM	Ultuna damm		6!◇	420 ±80◇	1000 ±150
250286	ROSDAMM	Rosendal damm		<4◇	<4◇	670 ±100

Övriga analyser

Analys	Klorofyll a
Id	EV:18
Enhet	µg/l
250281	6.66 ±1.7
250282	4.17 ±1.1
250283	11.5 ±3.0
250284	12.9 ±3.4
250285	39.8 ±10
250286	36.6 ±9.5

Resultaten gäller för proven såsom de har mottagits.
⁎ Ej ackrediterad analys. ! Mätvärdesspår. ◇ Analys utförd senare än metodregler. Se bilaga 3 för metodförteckning.
Den angivna osäkerheten är en utvidgad mätosäkerhet beräknad med en täckningsfaktor k=2.
Denna rapport får endast återges i sin helhet, om inte Erkenlaboratoriet i förväg skriftligen godkänt annat.

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761 73 Norrtälje

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018/471 28 58

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202100-2932

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Ackred. nr 1239 Provning ISO/IEC 17025

RAPPORT
Utfärdat av ackrediterat laboratorium
REPORT issued by Accredited Laboratory

Projekt	Uppsala dagvattendammar	**Kontakt**	Margarita Judina
Mottagare	Robyn Övergaard	**Uppdragsgivare**	Margarita Judina Risslingbyvägen 1 761 74 Norrtälje Sverige
Följesedel	25-68		
Rapportdatum	2025-05-16 15:00:43		
Kommentar			

Provinformation

Analys	Provplats	Provpunkt	Övrigt	Provtagningsdatum	Ankomstdatum	Provtyp
250389	NDAMM	Norra damm		2025-03-24	2025-03-24	Vatten
250390	SDAMM	Södra damm		2025-03-24	2025-03-24	Vatten
250391	BÄLDAMM	Bälinge damm		2025-03-24	2025-03-24	Vatten
250392	GOTDAMM	Gottsunda damm		2025-03-24	2025-03-24	Vatten
250393	ULTUNADAMM	Ultuna damm		2025-03-24	2025-03-24	Vatten
250394	ROSDAMM	Rosendal damm		2025-03-24	2025-03-24	Vatten
250395	ULTUNADAMM2	Ultuna damm 2		2025-03-24	2025-03-24	Vatten

Standardanalyser

Analys	Provplats	Provpunkt	Övrigt	pH	Konduktivitet	Alkalinitet	Turbiditet
Id				EV:1	EV:2	EV:4	EV:26
Enhet				25°	mS/m	mekv/l	FNU
250389	NDAMM	Norra damm		8.0 ±0.3⋄	25.6 ±1.5	1.6 ±0.14⋄	4.7 ±1.2
250390	SDAMM	Södra damm		7.9 ±0.3⋄	36.3 ±2.2	2.7 ±0.24⋄	3.4 ±0.85
250391	BÄLDAMM	Bälinge damm		7.3 ±0.3⋄	14.3 ±0.86	0.22 ±0.040	6.5 ±1.6
250392	GOTDAMM	Gottsunda damm		8.5 ±0.3	51.1 ±3.1	3.8 ±0.34	20 ±5.0
250393	ULTUNADAMM	Ultuna damm		8.6 ±0.3	57.7 ±3.5	4.2 ±0.38	11 ±2.8
250394	ROSDAMM	Rosendal damm		8.0 ±0.3	30.7 ±1.8	1.5 ±0.14	6.4 ±1.6
250395	ULTUNADAMM2	Ultuna damm 2		8.5 ±0.3	52.4 ±3.1	3.9 ±0.35	11 ±2.8

Fosforanalyser SEAL

Analys	Provplats	Provpunkt	Övrigt	Fosfatfosfor	Totalfosfor
Id				EV:41	EV:43
Enhet				μg/l	μg/l
250389	NDAMM	Norra damm		<2⋄	19 ±3.5⋄
250390	SDAMM	Södra damm		<2⋄	26 ±4.6⋄
250391	BÄLDAMM	Bälinge damm		<2⋄	20 ±3.5⋄
250392	GOTDAMM	Gottsunda damm		15 ±5.0⋄	39 ±7.0⋄
250393	ULTUNADAMM	Ultuna damm		7 ±2.5	54 ±9.7⋄
250394	ROSDAMM	Rosendal damm		110 ±25⋄	220 ±35⋄
250395	ULTUNADAMM2	Ultuna damm 2		18 ±4.6⋄	78 ±14⋄

Resultaten gäller för proven såsom de har mottagits.
∗ Ej ackrediterad analys. ! Mätvärdesspår. ⋄ Analys utförd senare än metodregler. Se bilaga 3 för metodförteckning.
Den angivna osäkerheten är en utvidgad mätosäkerhet beräknad med en täckningsfaktor k=2.

Postadress
Norra Malmavägen 45
761 73 Norrtälje

Telefon
018/471 28 57
018/471 28 58

Org.nr
202100-2932

Signatur
Helena Enderskog

Erkenlaboratoriet
Institutionen för Ekologi och Genetik
Uppsala Universitet

SWEDAC ACKREDITERING
Ackred. nr 1239
Provning
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RAPPORT

Utfärdat av ackrediterat laboratorium
REPORT issued by Accredited Laboratory

Projekt	Uppsala dagvattendammar	**Kontakt**	Margarita Judina
Mottagare	Robyn Övergaard	**Uppdragsgivare**	Margarita Judina Risslingbyvägen 1 761 74 Norrtälje Sverige
Följesedel	25-68		
Rapportdatum	2025-05-16 15:00:43		
Kommentar			

Kväveanalyser SEAL / Shimadzu

Analys	Provplats	Provpunkt	Övrigt	Ammoniumkväve	Nitrat+Nitritkväve	Totalkväve Shimadzu
Id				EV:44	EV:46	EV:57
Enhet				$\mu g/l$	$\mu g/l$	$\mu g/l$
250389	NDAMM	Norra damm		<4⋄	<4	360 ±54
250390	SDAMM	Södra damm		<4⋄	<4	500 ±75
250391	BÄLDAMM	Bälinge damm		<4	<4	250 ±38
250392	GOTDAMM	Gottsunda damm		10 ±3.1	6!	490 ±73
250393	ULTUNADAMM	Ultuna damm		6!	<4	570 ±86
250394	ROSDAMM	Rosendal damm		<4	<4	900 ±140
250395	ULTUNADAMM2	Ultuna damm 2		5!	17 ±3.7	550 ±82

Övriga analyser

Analys	Klorofyll a
Id	EV:18
Enhet	$\mu g/l$
250389	3.80 ±0.99
250390	6.98 ±1.8
250391	11.6 ±3.0
250392	17.5 ±4.5
250393	28.8 ±7.5
250394	40.0 ±10
250395	17.8 ±4.6

Resultaten gäller för proven såsom de har mottagits.
* Ej ackrediterad analys. ! Mätvärdesspår. ⋄ Analys utförd senare än metodregler. Se bilaga 3 för metodförteckning.
Den angivna osäkerheten är en utvidgad mätosäkerhet beräknad med en täckningsfaktor k=2.

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Mottagare	Robyn Övergaard	**Uppdragsgivare**	Margarita Judina Risslingbyvägen 1 761 74 Norrtälje Sverige
Följesedel	25-94		
Rapportdatum	2025-05-16 15:09:21		
Kommentar			

Provinformation

Analys	Provplats	Provpunkt	Övrigt	Provtagningsdatum	Ankomstdatum	Provtyp
250515	NDAMM	Norra damm		2025-04-09	2025-04-09	Övrigt
250516	SDAMM	Södra damm		2025-04-09	2025-04-09	Övrigt
250517	BÄLDAMM	Bälinge damm		2025-04-09	2025-04-09	Övrigt
250518	GOTDAMM	Gottsunda damm		2025-04-09	2025-04-09	Övrigt
250519	ULTUNADAMM	Ultuna damm		2025-04-09	2025-04-09	Övrigt
250520	ROSDAMM	Rosendal damm		2025-04-09	2025-04-09	Övrigt

Standardanalyser

Analys	Provplats	Provpunkt	Övrigt	pH	Konduktivitet	Alkalinitet	Turbiditet
Id				EV:1	EV:2	EV:4	EV:26
Enhet				25°	mS/m	mekv/l	FNU
250515	NDAMM	Norra damm		7.8 ±0.3	28.8 ±1.7	1.9 ±0.17	1.1 ±0.30
250516	SDAMM	Södra damm		7.8 ±0.3	39.4 ±2.4	2.9 ±0.26	2.0 ±0.55
250517	BÄLDAMM	Bälinge damm		7.3 ±0.3	15.0 ±0.90	0.27 ±0.049	4.9 ±1.2
250518	GOTDAMM	Gottsunda damm		8.3 ±0.3	52.4 ±3.1	4.1 ±0.37	9.5 ±2.4
250519	ULTUNADAMM	Ultuna damm		8.3 ±0.3	56.1 ±3.4	4.1 ±0.37	12 ±3.0
250520	ROSDAMM	Rosendal damm		8.4 ±0.3	35.1 ±2.1	1.8 ±0.16	5.0 ±1.2

Fosforanalyser SEAL

Analys	Provplats	Provpunkt	Övrigt	Fosfatfosfor	Totalfosfor
Id				EV:41	EV:43
Enhet				µg/l	µg/l
250515	NDAMM	Norra damm		<2⋄	19 ±3.4
250516	SDAMM	Södra damm		<2⋄	23 ±4.2
250517	BÄLDAMM	Bälinge damm		<2	21 ±3.9
250518	GOTDAMM	Gottsunda damm		3!	33 ±5.9
250519	ULTUNADAMM	Ultuna damm		7 ±2.5	64 ±11
250520	ROSDAMM	Rosendal damm		56 ±14	150 ±24

Resultaten gäller för proven såsom de har mottagits.
∗ Ej ackrediterad analys. ! Mätvärdesspår. ⋄ Analys utförd senare än metodregler. Se bilaga 3 för metodförteckning.
Den angivna osäkerheten är en utvidgad mätosäkerhet beräknad med en täckningsfaktor k=2.
Denna rapport får endast återges i sin helhet, om inte Erkenlaboratoriet i förväg skriftligen godkänt annat.

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Mottagare	Robyn Övergaard	**Uppdragsgivare**	Margarita Judina Risslingbyvägen 1 761 74 Norrtälje Sverige
Följesedel	25-94		
Rapportdatum	2025-05-16 15:09:21		
Kommentar			

Kväveanalyser SEAL / Shimadzu

Analys	Provplats	Provpunkt	Övrigt	Ammoniumkväve	Nitrat+Nitritkväve	Totalkväve Shimadzu
Id				EV:44	EV:46	EV:57
Enhet				μg/l	μg/l	μg/l
250515	NDAMM	Norra damm		<4	<4	370 ±56
250516	SDAMM	Södra damm		<4	<4	500 ±75
250517	BÄLDAMM	Bälinge damm		<4	<4	350 ±52
250518	GOTDAMM	Gottsunda damm		4!	<4	450 ±68
250519	ULTUNADAMM	Ultuna damm		5!	<4	470 ±70
250520	ROSDAMM	Rosendal damm		6!	<4	880 ±130

Övriga analyser

Analys	Klorofyll a
Id	EV:18
Enhet	μg/l
250515	2.96 ±0.77
250516	6.06 ±1.6
250517	11.8 ±3.1
250518	8.21 ±2.1
250519	10.5 ±2.7
250520	36.1 ±9.4

Resultaten gäller för proven såsom de har mottagits.
* Ej ackrediterad analys. ! Mätvärdesspår. ◇ Analys utförd senare än metodregler. Se bilaga 3 för metodförteckning.
Den angivna osäkerheten är en utvidgad mätosäkerhet beräknad med en täckningsfaktor k=2.

Postadress
Norra Malmavägen 45
761 73 Norrtälje

Telefon
018/471 28 57
018/471 28 58

Org.nr
202100-2932

Signatur

Helena Enderskog

Appendix E

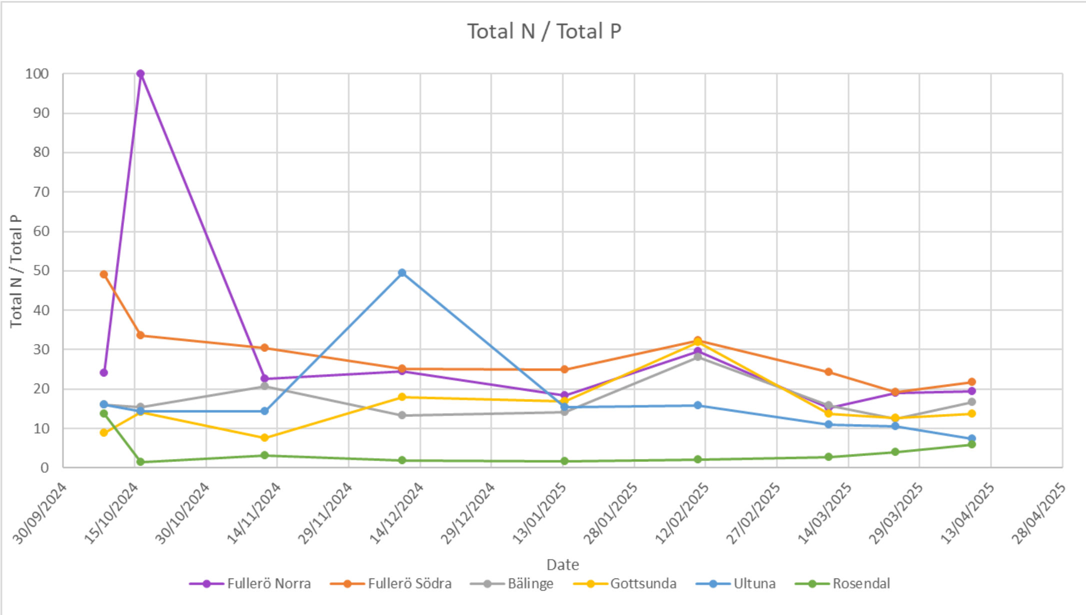


Figure E- 1: TN:TP ratio.

Appendix F

Figure F- 1: Floor plan. Bälinge. Extracted from drawing provided by Uppsala Vatten (Uppsala kommun, 2013).

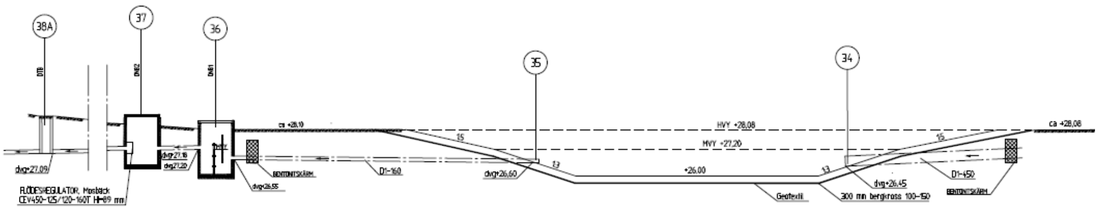


Figure F- 2: Longitudinal section. Bälinge. Extracted from drawing provided by Uppsala Vatten((Uppsala kommun, 2013).

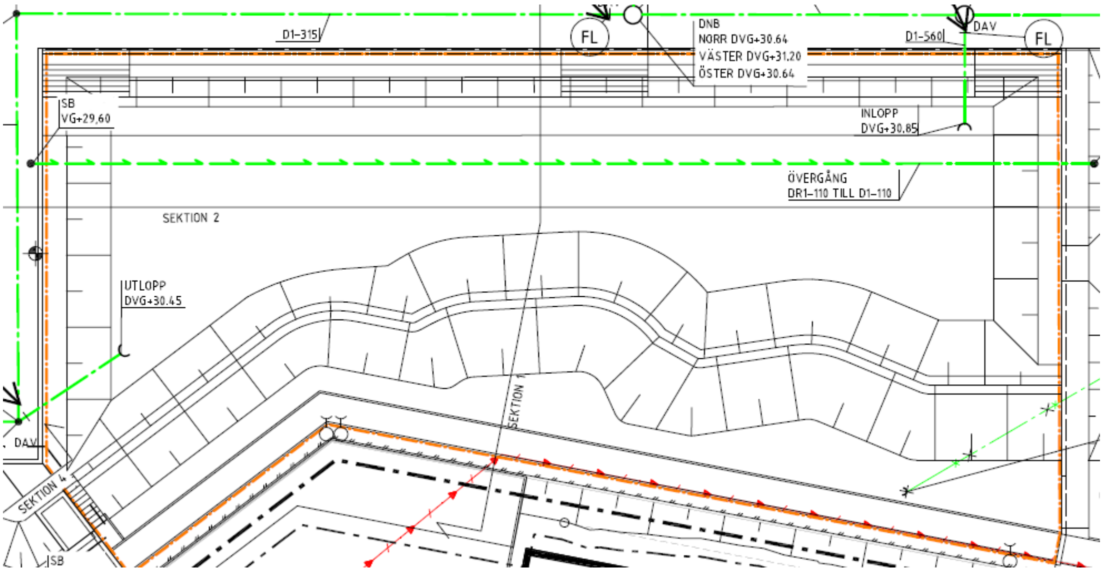


Figure F- 3: Floor plan. Rosendal. Extracted from drawing provided by Uppsala Vatten (Uppsala Vatten, 2021).

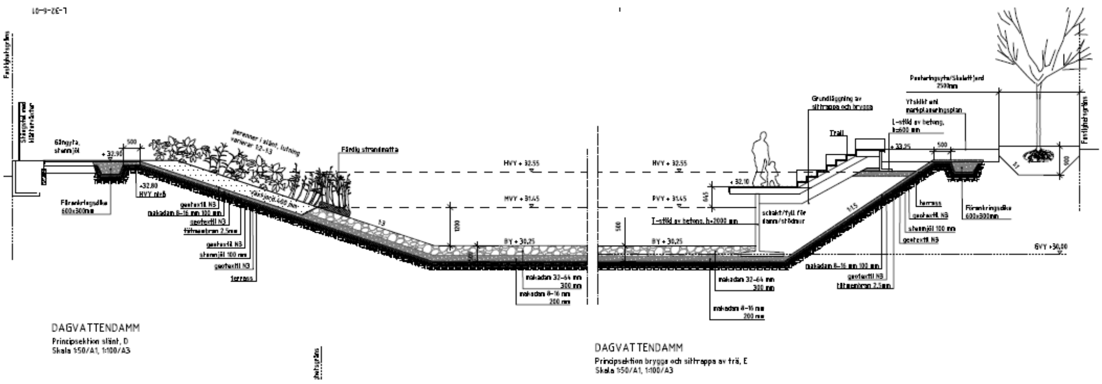


Figure F- 4: Cross section. Elsa Eschelssons Park. Extracted from drawing provided by Uppsala Vatten (Karavan Landskapsarkitekter, 2019).

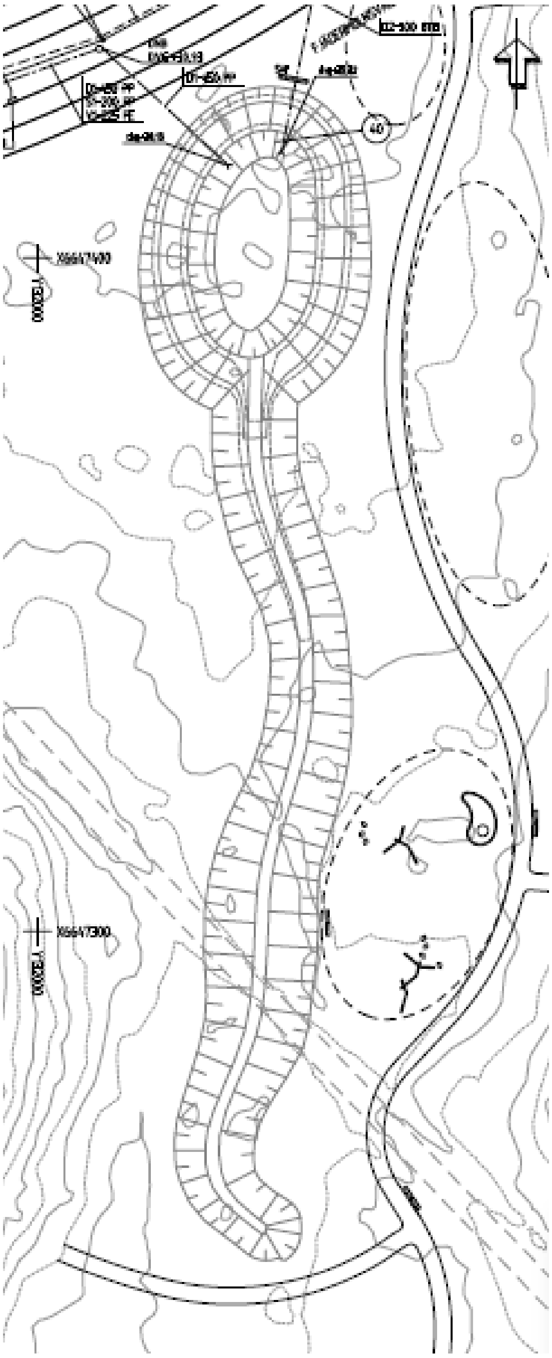


Figure F- 5: Floor plan. Fullerö southern pond. Extracted from drawing provided by Uppsala Vatten (Bjerking AB, 2017a).

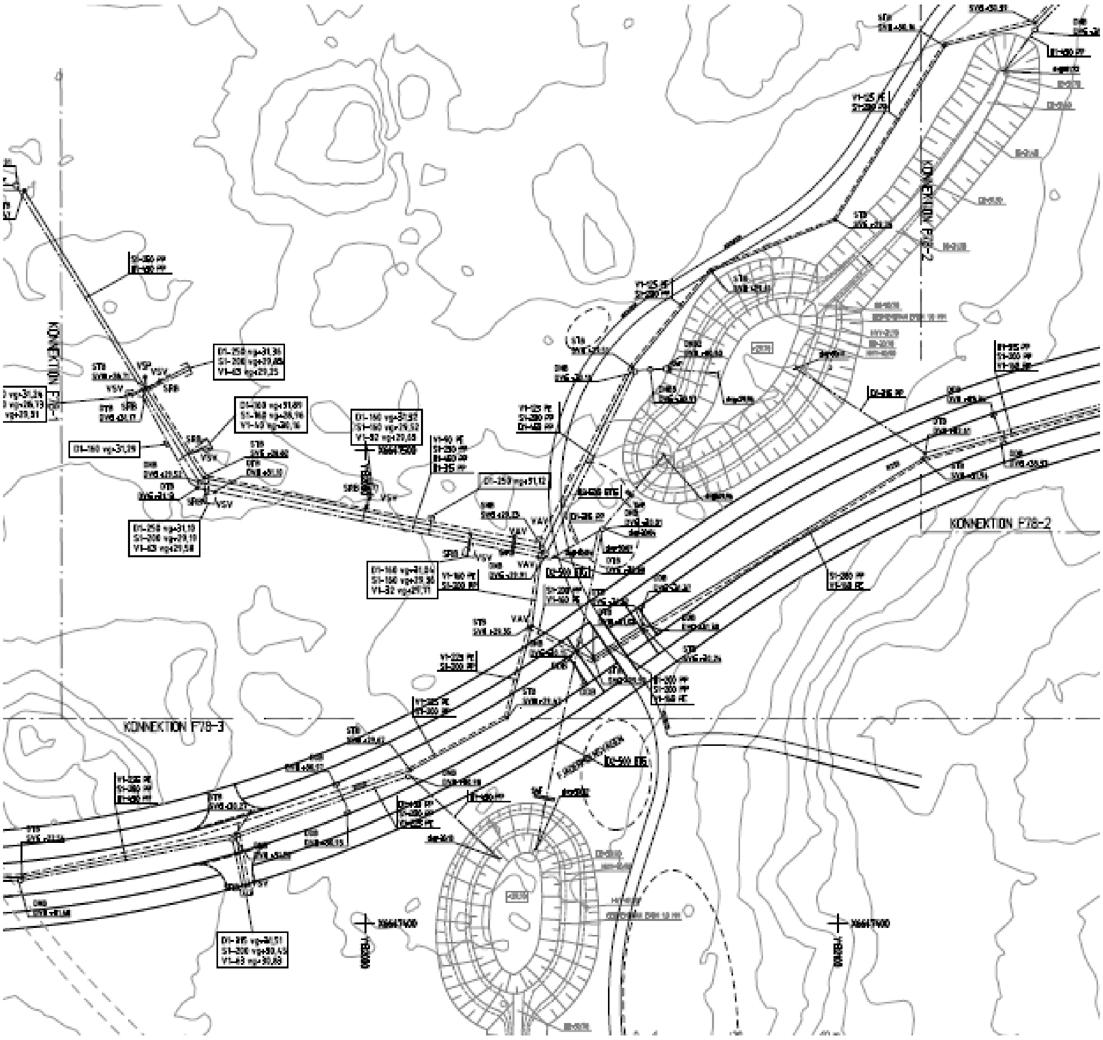
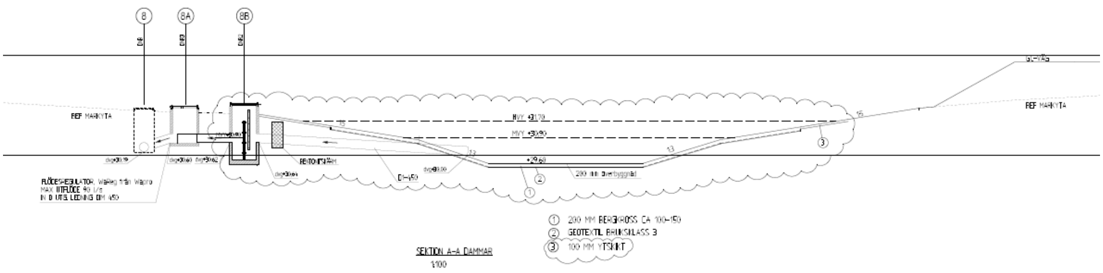


Figure F- 6: Floor plan. Fullerö Northern pond. Extracted from drawing provided by Uppsala Vatten (Bjerking AB, 2017b).

A



B

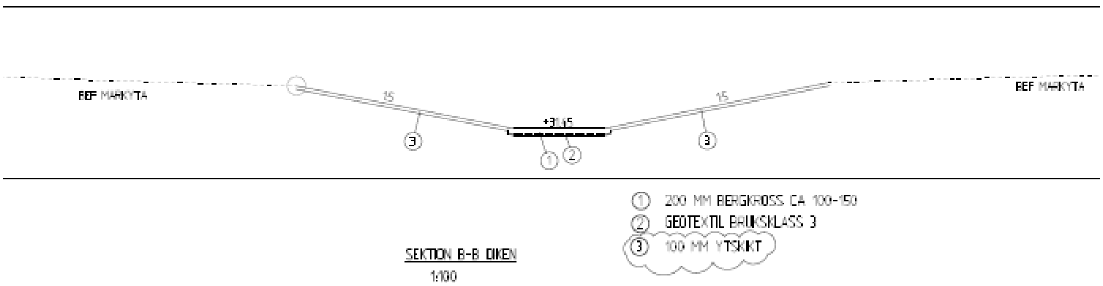


Figure F- 7: Longitudinal section of the ponds (A) and channels (B). Fullerö ponds. Extracted from drawing provided by Uppsala Vatten (Bjerking AB, 2016).

Appendix G

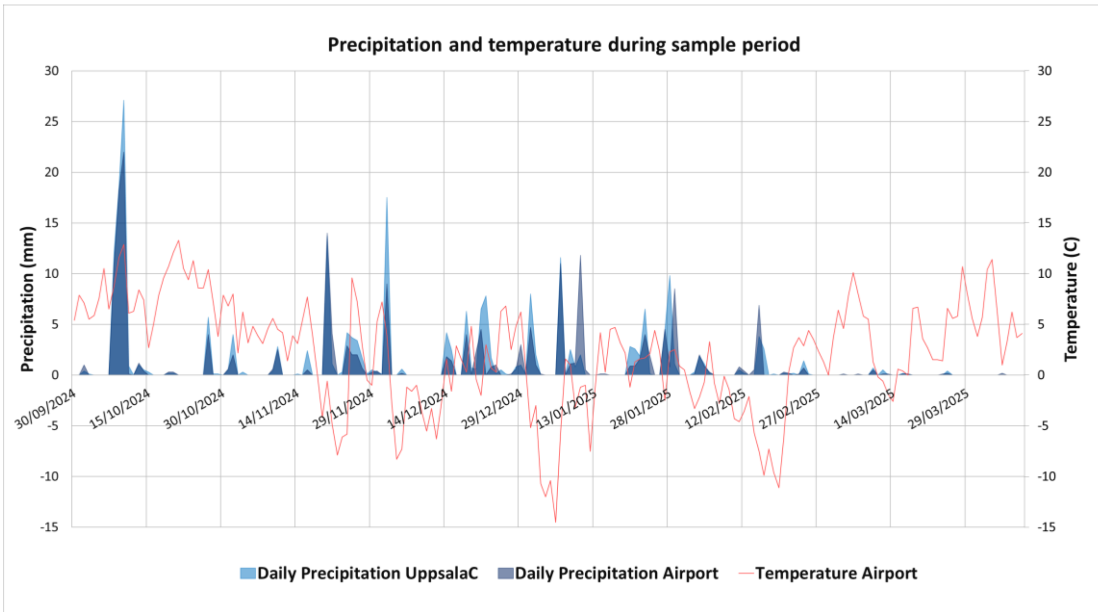


Figure G- 1: Precipitation and temperature data during sampling period (SMHI, u.d.).

Appendix H

Table H- 1: Summary of documents reviewed to make the comparison of the physical parameters of the studied ponds.

Storm water pond	**Literature**
Elsa Eschelssons park	*PM Rapport: Elsa Eschelssons park - Utformning av dagvattendamm.* - Bjerking (2020) *Kalkylhandling. Elsa Eschelssons park Uppsala. Detaljritning 1. Principsektioner för dagvattendamm L-32-6-01* - Karavan Landskapsarkitekter (2019) *Bygghandling, Elsa Eschelssons Park Uppsala. R-51.1-001. Brandmästargatan R-51.1-001 Driftläge DAV.* - Uppsala Vatten (2021)
Gottsunda Dagvattenpark	*Slutrapport Gottsunda Dagvattenpark: Kontrollprogram miljö (Uppdragsnr.: 108 55 49 Version: 1).* - Norconsult Sverige AB (2024) *Systemhandling för multifunktionell dagvattenpark i Södra Gottsunda.* - Stenström et al. (2019) *Kontinueliga sensormätninger av turbiditet som metod för att kvantifiera transport och avskiljning av föroreningar i dagvatten (masteruppsats).* – Svenda (2024) *Relationshandling, Gottsunda Dagvattenpark, Eksätravägen. R-51.1-04.* - WRS (2021a) *Relationshandling, Gottsunda Dagvattenpark, Eksätravägen. R-51.2-01.* - WRS (WRS, 2021b)
Ultunaallén	*Skötselplan för dagvattenanläggning Ultunaallén (våtdamm)* - Uppsala Vatten (2023c) *Utformning av dagvattendammar sträcka D (Uppdragsnr.: 108 25 76 Version: 6).* - Norconsult Sverige AB (2024b) *Bygghandling, Ultuna VA, Ultunaallén. del 3. U10-39.* - Karavan Landskapsarkitekter (2009)
Ekåkersvägen, Bälinge	*Skötselplan för dagvattenanläggning. Ekåkersvägen, Rörby/Bälinge (våtdamm).* - Uppsala Vatten (2023a) *Bygghandling, Rörby Bälinge, Ekåkersvägen B163-6.* - Uppsala kommun (2013)
Fjädermolnsvägen, Fullerö	*Skötselplan för dagvattenanläggning. Fjädermolnsvägen, Fullerö (våtdammar).* - Uppsala Vatten (2023b) *Relationshandling, Fullerö Bostäder, Fjädermolnsvägen. F78-03.* - Bjerking AB (2017a) *Relationshandling, Fullerö Bostäder, Fjädermolnsvägen. F78-12.* – Bjerking AB (Bjerking AB, 2017b)

Storm water pond	Literature
	Bygghandling, Fullerö Bostäder, Fjädermolnsvägen, F78-10. – Bjerking AB (2016)

TRITA – ABE - MBT - 25632
Stockholm, Sweden 2025

www.kth.se