A Toxic Legacy? A Study of PFAS Leakage from Landfills in the Eastern Part of Mälaren

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Master's Thesis

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Abstract

The growing concern around per- and polyfluoroalkyl substances (PFAS) and their negative health and environmental effects have lately become more apparent which also is reflected in the new, more strict regulations of permitted levels of PFAS in drinking water extracted from water resources. However, many point sources of PFAS pollution to the environment and to water resources are still not identified and assessed for risk. This is also the case around the Mälaren-Görväln which is used as a drinking water resource. Work has been initiated to map sources of PFAS pollution to the water resource. However, hitherto, the risk of PFAS pollution from landfills surrounding the water intake is under-studied. This thesis has thus tried to address the issue by investigating landfills' potential PFAS contribution to Mälaren-Görväln water body.

Active and inactive landfills which are located within the Östra Mälaren water protection area have been researched. Furthermore, field sampling and measurements of PFAS in surface water have been conducted in connection with three landfills within the water protection area and in Brobäcken. Data from the Högbytorp facility which incorporates three landfills has also been used for comparison. The PFAS load from the landfills to Mälaren-Görväln has been estimated. Lastly a principal component analysis (PCA) has been carried out to trace the sources of sampled PFAS levels.

The research of landfills located within the water protection area, led to identification of 32 different landfills of which almost all are believed to be inactive. All field samples taken in connection to Skå, Svartsjö and Johannelund landfill indicated levels of PFAS. The levels detected were lower than the levels measured downstream Högbytorp and in Brobäcken. At all sampling locations, including downstream Högbytorp and excluding the sample by Svartsjö, the levels detected exceed at least one current guiding and soon to be limiting value. The estimated mass flows of PFAS received at the sampling locations showed that landfills can potentially account for a considerable share of the estimated loads to Mälaren-Görväln. However, the results should be interpreted with caution due to the small dataset analysed and as it proved to be difficult to determine specifically the landfills' share of the PFAS concentrations detected as the other potential sources of PFAS can have an influence on the sampled surface water.

It remains to carry out a more in-depth risk assessment of the landfills' potential impact on Mälaren-Görväln where, among other things, PFAS pollution to the soil and groundwater are included. Further, more research of all identified landfills is needed to estimate the cumulative potential impact of landfills’ PFAS load to Mälaren-Görväln and the extracted drinking water.

Keywords
Landfills, PFAS, Leachate, Mälaren-Görväln, Östra Mälaren Water Protection Area, Norrvatten, Drinking Water, Characterisation, Risk Assessment

Sammanfattning

Det växande problemet kring per- och polyfluoralkylsubstanser (PFAS) och deras negativa hälso- och miljöeffekter har på senare tid blivit allt mer uppenbar. Angelägenheten återspeglas i nya och striktare regler för tillåtna halter av PFAS i dricksvatten som utvinns från vattenresurser. Flertalet punktkällor för PFAS-föroreningar som påverkar miljö och vattenresurser är varken identifierade eller riskbedömda. Så är även fallet för Mälaren-Görväln som används som en dricksvattenresurs. Visserligen har arbete inletts för att kartlägga källor av PFAS-föroreningar till Mälaren-Görväln. Däremot saknas undersökningar om risken för PFAS-förorening kring vattenresursen. I syfte att fylla föregående nämnda forskningsgap, syftar denna avhandling till att studera deponiers potentiella PFAS-bidrag till Mälaren-Görvälns vattenförekomst.

Inom ramen för studien har både aktiva och inaktiva deponier inom Östra Mälarens vattenskyddsområde undersökts. Vidare har fältprovtagning och mätningar av PFAS i ytvatten genomförts i anslutning till tre deponier inom vattenskyddsområdet och i Brobäcken. Data från Högbytorps anläggning som innefattar tre deponier har även använts för jämförelse. PFAS-belastningen från de studerade deponierna till Mälaren-Görväln har uppskattats. Slutligen har en principalkomponentanalys (PCA) genomförts för att spåra källorna till provtagna PFAS-nivåer.

Undersökningen resulterade i identifiering av 32 olika deponier varav nästan alla tros vara inaktiva. Alla provtagningar som tagits i anslutning till deponierna Skå, Svartsjö och Johannelunds visar uppmätta halter av PFAS. De påvisade halterna var lägre än de halter som uppmätts nedströms Högbytorp och i Brobäcken. På alla provtagningsplatser, inklusive nedströms Högbytorp och exklusive provtagning vid Svartsjö, överstiger de påvisade halterna minst ett vägledande och framtida gränsvärde. De uppskattade massflödet av PFAS vid provtagningsplatserna visade att deponier potentiellt kan stå för en betydande andel av de beräknade belastningarna till Mälaren-Görväln. Resultaten bör dock tolkas med försiktighet på grund av den lilla datauppsättning som har analyserats och eftersom det visade sig vara svårt att specifikt bestämma deponiernas andel av de PFAS-koncentrationer som uppmätts.

Andra potentiella PFAS källor i anslutning till deponierna kan ha en inverkan på de ytvatten som har provtagits i studien.

Framtida forskning bör utföra en mer djupgående riskbedömning av deponiers potentiella påverkan på Mälaren-Görväln där även PFAS-föroreningar till mark och grundvatten bör ingå. Avslutningsvis efterfrågas vidare undersökning av den kumulativa potentiella påverkan av deponiers PFAS-belastning på Mälaren-Görväln och det extraherade dricksvattnet.

Nyckelord
Deponier, PFAS, Lakvatten, Mälaren-Görväln, Östra Mälarens vattenskyddsområde, Norrvatten, Dricksvatten, Karakterisering, Riskbedömning,

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Acronyms and Abbreviations

DARO	In Swedish “Delavriningsområde” meaning partial catchment area
EBH	In Swedish “EfterBeHandling”, a database of the County Administrative Board’s collected information about potential polluted areas in the country (Sweden)
EFSA	European Food Safety Authority
HARO	In Swedish “Huvudavrinningsområden” meaning the main catchment area
Kd	Soil-water partition coefficient
Koc	Organic carbon-water partition coefficient
LOR	The Reporting limit
MIFO	Methodology For Inventory
MKN	In Swedish “Miljökvalitetsnorm” which can be translated to Environmental Quality Standard in English
OECD	The International Organisation for Economic Cooperation and Development
POPs	Persistent Organic Pollutants
QGIS	Geographical Information System
SGU	Geological Survey of Sweden
S-HYPE	Sweden-Hydrological Predictions for the Environment (A water flow model)
SMHI	Swedish Meteorological and Hydrological Institute
TOC	Total Organic Carbon
VARO	In Swedish “Vattenförekomstavrinningsområde” which can be translated to water body catchment area
VISS	Water Information System Sweden

ÅVC	In Swedish "Återvinningscentral" which can be translated to a waste recycling centre

PFAS Terminology

PFAS	Per- and polyfluoroalkyl substances
PFAA	Perfluoroalkyl acids
PFCA	Perfluoroalkyl carboxylic acids
PFSA	Perfluoroalkane sulfonic acids

Individual PFAS

PFBA	Perfluorobutanoic acid
PFPeA	Perfluoropentanoic acid
PFHxA	Perfluorohexanoic acid
PFHpA	Perfluoroheptanoic acid
PFOA	Perfluorooctanoic acid
PFNA	Perfluorononanoic acid
PFDA	Perfluorodecanoic acid
PFBS	Perfluorobutane sulfonic acid
PFHxS	Perfluorohexane sulfonic acid
PFOS	Perfluorooctane sulfonic acid
6:2 FTS	6:2 Fluorotelomer sulfonic acid
∑PFAS - 4	The sum of PFOS, PFOA, PFNA, PFHxS
∑PFAS - 11	The sum of the 11 individual PFAS described above
∑PFAS - 21	The sum of all in ∑PFAS -11 in addition to PFUnDA, PFDoA, PFTrDA, PFPeS, PFHpS, PFNS, PFDS, PFUnDs, PFDoS and PFTrDs

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1. Introduction

1.1 Background

Of all water existing on earth today less than 3 % is freshwater and the majority of the freshwater is made up of the glaciers and ice caps. That implies that freshwater present in the atmosphere, lakes, rivers and in soils, which is essential for lives and human livelihood, is in reality a very small fraction of all water existing on earth (less than 1 %) (Shiklomanov, 1993). For us humans, freshwater is vital, as it offers us water for drinking, sanitation, cooking, food production and cultural benefits. Freshwater is a result of functioning ecosystems and the natural cycling of water (Rockström and Klum, 2012). However, today, many freshwater ecosystems around the globe are under pressure due to our human activities. Increasing population densities, climate change and land use are some of the driving forces which have changed the natural water cycles, impacting the freshwater availability. Pollution of freshwater sources is another key threat for the freshwater quality (UNEP, 2022). Access to clean and safe drinking water is thus an increasing concern and nothing that today can be taken for granted not in Sweden either, despite the favourable conditions for freshwater availability in the ground and in lakes and rivers (SGU, 2020).

Mälaren, the third largest lake in Sweden to the surface, currently provides drinking water to around 2 million people (Malnes et al., 2021). At the same time the Mälaren has not been spared from anthropogenic activities and threats explained above (Norrvatten, 2020). In a report delivered by Mälaren water Conservation association (Malnes et al., 2021) it has been stated that Mälaren has 2-8 times higher cumulative (summed) levels of organic pollutants compared to the two other large lakes in Sweden, Vänern and Vättern. The level of dissolved organic material has also increased the last couple of years which challenges the production of clean drinking water (Mälaren Vattenvårdsförbund, 2023).

The concern for mismanagement of drinking water sources has recently led to stricter regulations. In line with the EU directive (2020/2184) concerning the quality of water intended for human consumption, freshwater catchment areas where drinking water is abstracted should be characterised, assessed for risks and monitored. Accordingly, possible contaminants and their sources affecting the catchment areas and the quality of the drinking water are covered by such a control process. As a consequence of these regulatory demands Norrvatten as one of the largest drinking water suppliers in Stockholm are advancing their work on securing the future quality of the drinking water in Östra Mälaren (Norrvatten, 2021a). Norrvatten has among other things initiated projects focusing on characterisation and risk assessment of the syntetically produced chemical group named PFAS (Per- and polyfluoroalkyl substances) (Ekman and Ejhed, 2022).

PFAS, which is commonly labelled "the forever chemical" due to its resistance to decomposition, is widely used in society and spread in the environment and has proven to be toxic and persistent (Kemikalieinspektionen, 2022). Humans are commonly exposed to PFAS via food and drinking water, but also through indoor air, dust and PFAS containing consumer products. The exposure of PFAS through drinking water has been considerable at locations where the drinking water has been contaminated by PFAS, for example from fire drills (Livsmedelsverket, 2022a). At present, new limitations of allowed concentrations of PFAS in drinking water on a national and EU level are on their way, which also implies that water distributors such as Norrvatten must prepare to live up to these requirements (SVOA, 2023).

1.1.1 Norrvatten

Norrvatten is a municipal organisation which today produces drinking water reaching around 700 000 people in the northern parts of Stockholm. Every second approximately 1600 litres of drinking water is produced in Görvälnverket (Järfälla municipality), where Norrvatten abstracts the water (Norrvatten, 2022). The drinking water is received from the raw-water in Mälaren-Görväln, a partial basin in the eastern part of Mälaren (Ekman and Ejhed, 2022). As the fourth largest drinking water producer in Sweden, Norrvatten's vision is to deliver high-quality and healthy drinking water, while at the same time focusing on the environment and the community benefits (Norrvatten, 2022). Norrvatten and all other drinking water distributors in Sweden are responsible for ensuring that the drinking water they distribute is safe to drink (LIVSFS 2022:12). Furthermore, Norvatten's mission is to build, maintain and operate waterworks, water towers, pumping stations and pipes all the way to each member municipality's own water supply network (Norrvatten, 2022).

1.1.1.1 Norrvatten's Work with PFAS in Mälaren

As highlighted by Norrvatten (2020), PFAS is considered a risk for the future drinking water quality in Mälaren. PFOS is today registered as a contaminant exceeding the environmental quality standard in Mälaren-Görväln, as well as for many other surface waters in Mälaren, according to the latest water framework classification (VISS, 2023).

Today, Norrvatten has no efficient treatment for PFAS (Ekman and Ejhed, 2022), but Norrvatten has plans for implementing a chemical cleaning technique using activated carbon if the quantities of PFAS do not decrease in the raw water and as a preventive measure to make sure that decreasing limit values of PFAS concentrations in drinking water can be met (Norrvatten, 2021a). In the long run, PFAS cleaning at the waterworks, however, is rather a burden than a benefit to the environment, also financially (Ekman and Ejhed, 2022). With active upstream work, the spread of PFAS can be avoided to a larger extent, as protective measures could be enabled at the point sources of contamination which hampers the circulation of PFAS from the point source and onwards in the global cycle which is beneficial for ecosystems and human health in a broader sense (SVOA, 2023).

Norrvatten has already initiated upstream work with the goal of calculating the PFAS mass balance of the water body catchment area (VARO) Mälaren-Görväln. This has been performed by Ekman and Ejhed (2022). In the conclusion of their study, it is highlighted that knowledge of more point sources of PFAS and the scale of PFAS-sources in relation to each other is still lacking in order to provide a more comprehensive picture of PFAS mass in the Mälaren-Görväln. For example, sources contributing to 44 % of the measured PFOS load in Mälaren-Görväln could not be reported due to uncertainties and missing data.

This pinpoints the importance for further work focusing on identifying and mapping point sources of PFAS in the area, upstream of the water abstraction point. Landfills have been identified as one potential key source of PFAS release to the environment (Hansson et al., 2016, Naturvårdsverket, 2019), however, limited amounts of studies exist which report upon levels and distribution of PFAS in different leachate waters produced at landfills in the region of Mälaren (Ekman and Ejhed, 2022). The current thesis intends to contribute to Norrvattens upstream work, by investigating landfills as a potential point source of PFAS in Östra Mälaren.

1.3 Aim and Objectives

The aim of this thesis is to characterise, map and quantify the discharge of PFAS from landfills in the water protection area surrounding Norrvatten's drinking water abstraction point in Mälaren-Görväln, in order to contribute to a more comprehensive understanding of PFAS sources and pathways and to lay ground for future work to limit PFAS pollution to the water and subsequently in the abstracted drinking water.

This will be achieved through the following objectives:

- Identification of active and inactive landfills within the Eastern area of Mälaren (especially focusing on the water protection area named Östra Mälaren) and comparison with the previous compilation used in the PFAS mass balance report by Ekman and Ejhed (2022).

- Conducting field sampling and measurements next to landfills within the water protection area to collect PFAS, water physico-chemistry and water flow data used for further analysis of PFAS load and potential sources.

- Calculating the load of PFAS discharging from the landfills, based on the sampling collected next to the landfills, using the levels of PFAS measured and calculated water flows to evaluate its potential share to the total load of PFAS in Mälaren-Görväln.

- Analysing the collected field data and comparing it to existing data and research on the topic, aiming to trace sources of PFAS leakage.

1.4 Research Methodology

In order to fulfil the thesis' aim and objectives both qualitative and quantitative data has been collected about PFAS and its interrelation with landfills in the study area. Data existing about landfills in the study area has been collected from governmental authorities' databases and literature. Own sampling and measurements of PFAS and water chemistry parameters has also been performed in connection to three of the focused landfills in the study. Data of PFAS and water chemistry measurements connected to the fourth landfill area in focus has been accessed by Ragn-Sells which is managing the operation. Literature research has also been conducted to try to comprehend the current understanding of PFAS and landfills in general and in the targeted study area.

In order to interpret the collected data, excel has been used for representing the data in tables and graphs. Furthermore, the geographical information system (GIS) program called QGIS has been used for storing and visualisation of the collected information of landfills while statistical analysis of the PFAS and water chemistry data has been performed using the principal component analysis (PCA) method. Also, estimates of the load (mass) of PFAS from the landfills in focus have been performed using the accessed PFAS concentrations and calculated water flows. The results have been compared with each other and with previous measured and calculated results found in literature.

1.5 Delimitations

This thesis focuses specifically on sources of PFAS pollution in the water protection area called Östra Mälaren where Görvälnverket, Norrvattens drinking water abstraction operation is located. Due to the scope of the study, only landfills as sources of PFAS have been investigated. The PFAS in focus are the ones regulated by the Swedish drinking water regulations (LIVSFS 2022:12), namely PFAS-4, PFAS-11 and PFAS-21. However, a variety of different types of PFAS from different uses have been briefly described. Foremost, the focused PFAS present in surface water upstream and downstream of landfills are included in the scope of the study. PFAS present in the groundwater or in the soil surrounding the landfills have not been examined. Despite the fact that several landfills present within the study area have been identified and geographically placed, the load of PFAS on the Östra Mälaren water protection area from them all has not been quantified due to limited time. Only three landfills are extensively investigated in this study as well as one landfill area outside the boundary of the water protection area. The fourth landfill area is included due to the fact that PFAS data associated with the landfill area is available and also, because the discharge from the landfill area ends up within Mälaren-Görväln catchment area.

2. Theory

2.1 PFAS

PFAS is a collective name for perfluoroalkyl chemicals, a large group of over 10 000 substances (Kemikalieinspektionen, 2022). As a matter of fact it is not known exactly how many PFAS that are circulating in the society today (Svenskt Vatten, 2022). All PFAS are synthetically produced, meaning that they are manufactured by humans and do not occur naturally in the environment and they all have in common that they are very difficult to decompose (Kemikalieinspektionen, 2022).

PFAS was first inventend in the 1930s by a coincidence in a laboratory at the company DuPont where it was realised that the substances had many useful characteristics. In the 1940s it started to be used as a constituent in the production of teflon and subsequently more and more different forms of PFAS were invented and became at hand for the world market (Sparrenbom and Jeppson (red), 2022). Already in the period within the 50s and 60s, the companies producing PFAS started to suspect that PFAS could be harmful to both the environment and human health, however, it was first in the 1970s that the negative effects with the use of PFAS in society started to appear in public and first in the early 2000 engagement around restricting PFAS manufacturing began to be taken more seriously (Svenska Vatten, 2022).

2.1.1 Chemical and Physical Characteristics of PFAS

Perfluoroalkyl chemicals are organic chemicals, consisting of carbon chains where hydrogen atoms are exchanged to fluorine atoms (Kemikalieinspektionen, 2022).

The Swedish Chemicals Agency uses the definition of PFAS which was suggested by OECD (Organisation for Economic Cooperation and Development) in 2021 and which has been acknowledged in broad communities (Kemikalieinspektionen, 2022). This definition follows:

"*PFASs are defined as fluorinated substances that contain at least one fully fluorinated methyl or methylene carbon atom (without any H/Cl/Br/I atom attached to it), i.e. with a few* *noted exceptions, any chemical with at least a perfluorinated methyl group (–CF3) or a perfluorinated methylene group (–CF2–) is a PFAS*." - OECD (2021)

PFAS are often divided into two general groups, polymeric or non-polymeric PFAS. What usually differentiates polymeric PFAS from non-polymeric PFAS is the chemical arrangement, were polymeric PFAS have long chains with smaller molecules while non-polymeric PFAS often have a functional group (i.e. a carboxyl or a hydroxyl group) bound to the carbon chain (Kemikalieinspektionen, 2022, Avfall Sverige, 2018).
Polymeric PFAS have longer chains than non-polymeric PFAS, often over 13 atoms. However, a non-polymeric PFAS can still be referred to as a long-chain PFAS. For example, perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) (chemical composition can be seen in Figure 1), are considered long-chained, despite that they both only have eight carbon atoms. Perfluorohexanoic acid (PFHxA) and perfluorohexane sulfonate (PFHxS), however, are generally referred to as short-chain PFAS, both consisting of six carbon atoms (Kemikalieinspektionen, 2022).

Within these two main groups there are also several subgroups. Perfluoroalkyl acid (PFAA) (non-polymeric) is one of the most studied subgroups of PFAS, from an environmental point of view (Avfall Sverige, 2018). Many polymeric and non-polymeric PFAS can break down to PFAA in biota and in the environment, and are then so-called precursors to PFAA. For example, 6:2 Fluorotelomer sulfonic acid (6:2 FTS) is a precursor to PFHxA and PFOA (Kemikalieinspektionen, 2021). PFAA and two of its subgroups are further presented in Table 1.
What makes PFAS so persistent and difficult to break down is the bond between carbon and fluorine which is extremely strong. Hitherto, no study has shown that any PFAS can decompose naturally in the environment, however, as described above PFAS can break down to another PFAS, yet very slowly (Kemikalieinspektionen, 2022).

The length of the carbon chain, the number of attached fluorine and the arrangement of the coal chain and potential added functional groups are all parameters which can be combined in many different ways, thus also enabling industrial manufacturing of a large variety of different PFAS (Kemikalieinspektionen, 2021).

The arrangement and structure of the atoms of a PFAS also gives it specific properties which decide its behaviour in the environment. For example, it is suggested by research (Malovany et al., 2021) that longer carbon-fluorinated chains bioaccumulate to a higher degree than shorter ones.

Common characteristics of PFAS is that they are hydrophobic (water repellent) and hydrophilic (water soluble) at the same time, which make PFAS excellent as a layer, separating for example a liquid and solid surface. This quality is what, among other things, make PFAS highly useful in many industrial products (Kemikalieinspektionen, 2022). It is the fluorinated carbon chains that entail the hydrophobic characteristic while, typically, the attached functional group is the hydrophilic component (Sparrenbom and Jeppson (red), 2022).

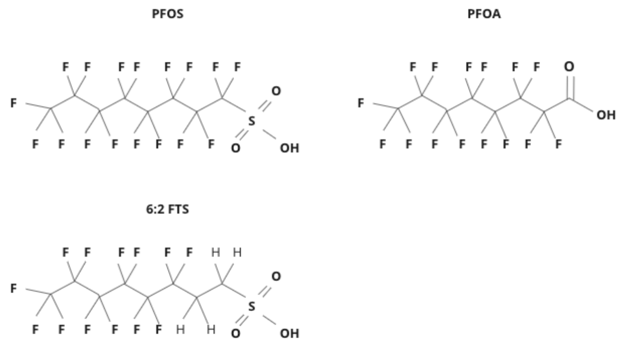

Figure 1. Chemical structure of three different PFAS. Reproduced based on an illustration in Sparrenbom and Jeppson (red) (2022).

Table 1. A few subgroups of PFAS. The table is adopted from Avfall Sverige (2018) .

Abbreviation	**Full name**	**Explanation**
PFAA	Perfluoroalkyl acids	PFAS which are organic organic acids. Extremely stable.
PFCA	Perfluoroalkyl carboxylic acids	A subgroup of PFAA where PFAS has a carboxylic acid group (-COOH), for example PFOA, PFBA, PFNA and PFHxA
PFSA	Perfluoroalkane sulfonic acids	A subgroup of PFAA where PFAS has a sulfonic group (-SO_2OH), for example PFOS and PFHxS

2.1.2 PFASs Effects on Human Health and Environment

According to Kemikalieinspektionen (2022), sufficient evidence exists for establishing that PFAS have negative effects on the environment and to human/animal health.
PFOA and PFOS are both classified as toxic to reproduction and are suspected cancerogenic. Furthermore, PFAS exposure at certain levels is suspected to affect the immune system and is believed to be an endocrine disruptor (Sparrenbom and Jeppson (red), 2022; Kemikalieinspektionen, 2022).

Despite that many PFAS can be classified depending on their persistency in the environment, knowledge about how most PFAS affect the health and the environment, i.e. the biological consequences, are yet unknown due to scarcity of data on the effects and exposure on the majority of the PFAS (Cousins et al., 2022; Kemikalieinspektionen, 2022; US EPA, 2023). As of today, most research on biological risk has been done on PFOA, PFOS, PFHxS and PFNA (Cousins et al., 2022).

From PFAS released to the environment, humans are primarily exposed to PFAS through food (i.e. fish, fruits and egg) and drinking water. But also via the air and dust (Livsmedelsverket, 2022a). As it passes through the body it does not decompose, however as PFAS rejects water and fat, it sticks to proteins, rather than to fatty tissues. In the body PFAS is thus often found in for example the blood, the kidneys or in the liver. Furthermore, as PFAS is bioaccumulative, elevated concentrations of PFAS occur at higher levels of the food chain (Sparrenbom and Jeppson (red), 2022).

2.1.3 Use in the Society

Due to their water and fat repellent characteristics, which is quite unique, and as they can endure high temperatures, PFAS are used in a large variety of products on the global market (Livsmedelsverket, 2022a). For example, PFAS are used in textiles, paper packaging, plastics, firefighting foams and in cleaning agents, paint and glue. PFAS are also found within electronics and engineering manufacturing as well as in cosmetics (Naturvårdsverket, 2019). Rain clothes, outerwear and furnishing fabrics are examples of textiles where PFAS are commonly used where both fat and water repellent qualities are often desired. Through these qualities PFAS create a valued surface, also present in, for example, teflon pans, popcorn packages and pizza boxes (Sparrenbom and Jeppson (red), 2022). In Table 2 examples of different PFAS that are used in everyday products are presented.

The most commonly used and most well-studied PFAS are PFOS and PFOA and as knowledge about these two substances has increased, both have been banned. Since 2011 it has been forbidden to use PFOS in new products globally and from 2020 the same applies to PFOA (Ekman and Ejhed, 2022). Also, chemicals that can form PFOA (precursors) during degradation were banned in the EU and since February 2023 six different PFAS substances PFNA, PFDA, PFUnDA, PFDoDA, PFTrDA and PFTeD as well as all other PFAS that can break down to these (around 200 PFASs) have been banned within the EU (Svenskt Vatten, 2022). Furthermore, a new EU-ban proposed by Sweden, Norway and Denmark, Holland and Germany in January 2023 can potentially stop all production and sale of PFAS. The proposal includes the entire supply chain which implies that use in production as well as in imported goods to the EU are covered (Miljøstyrelsen, 2023).

Table 2. Different PFAS present in commonly used products in society. The table is reproduced based on Kemikalieinspektionen (2022).

Products	**Example Uses**	**Common PFAS present**
Firefighting Foam (AFFFS)	Class B foam used on flammable liquids, especially petroleum fires	Precursors to 6:2 FTS and PFHxA, PFOA
Paper impregnation	Pizza boxes, Popcorn bags, cartons	PAPs/diPaps, 6:2 FTS, PFOA
Fabric/leather impregnation	Furniture fabrics, bags, shoes	PTFE, FTOH, FTS, PFOA
Cosmetics	Sunscreen, make up, foundation cream	PAPs/diPaps, PFCA
Household items	Paints, cleaning products, Ski wax, floor polish, non-stick pans	FTOH, PTFE (Teflon), PFOA, PFHxA

2.1.4 Key Sources and Pathways of PFAS

According to Kemikalieinspektionen (2023) it is estimated that around 75000 tons of PFAS every year are released to the environment in Europe. Textiles, fluorine gases and medical equipment accounts for a large part of the emissions (Kemikalieinspektionen, 2023). PFAS can be released from a product during its whole life cycle, from the cradle to the grave (Ahrens and Bundschuh, 2014).

Naturvårdsverket (2019) states that some of the most relevant potential sources of PFAS pollution are contaminated sites where firefighting foam has been used, landfills, sewage treatment plants and industries where PFAS have been used in large-scale, that is for example paper-, textile- and plastic industries. These are all so-called direct point sources of discharge of PFAS (Ahrens and Bundschuh, 2014). According to Kemikalieinspektionen (2022) the largest point sources of PFAS pollution load identified in Sweden are from the use of firefighting foam at fire training sites where high levels of PFAS have been measured in the surface water, groundwater and drinking water (Kemikalieinspektionen, 2022).

Emission sources of PFAS can also be more diffuse such as from precipitation and urban surface run-off (Ahrens and Bundschuh, 2014). According to Hansson et al., 2016, PFAS levels in precipitation contribute to around 10 times larger load of PFAS emissions to the Swedish environment compared to the contribution from firefighting foam usage at the airports' fire training sites. The atmospheric deposition of PFAS can be understood as a consequence of the large spread of PFAS on the global level and Cousins et al., 2022 argue that the levels of PFAS spread globally actually means that the planetary boundary for chemical pollution has been transcended.

PFAS has been found almost everywhere in the environment (Cousin et al., 2020), even at the most remote places such as the Arctic and Antarctic areas. In the environment the PFAS pollutants are transported through the whole hydraulic cycle, spread through the ground, groundwater, surface water, atmosphere and precipitation (Sparrenbom and Jeppson (red), 2022).

Many PFAS have high water solubility and low volatility, thus it is common that PFAS are found in surface and groundwater. Short chain PFAS is especially believed to have a tendency to high water solubility and lower partition constant between organic coal and water (Koc), that is, they are distributed to a lesser extent in the solid or organic phase which also means that they are mobile in soil and groundwater. Long chain PFAS is, however, more prone to bind to solid material. This means that Koc and the soil water partition coefficient

(Kd) varies for different PFAS depending among other things on the carbon-chain length (Sparrenbom and Jeppson (red), 2022; Ahrens and Bundschuh, 2014).

2.1.5 PFAS and Drinking Water

2.2.5.1 Swedish and European Regulations and Recommendations

On 1 of January 2023 the EU directive (2020/2184) regulating PFAS in drinking water was implemented into Swedish law, which implies that from 1 of January 2026 the limited values of PFAS in drinking water will be restricted even more. The Swedish Food Agency (Livsmedelsverket) has stipulated that the new allowed sum of PFOS, PFOA, PFHxS and PFNA (PFAS-4) in Swedish drinking water will be a maximum of 4 ng/L. Furthermore, the sum of 21 different PFAS including PFAS-4 will be limited to 100 ng/L (Livsmedelsverket, 2022b). Denmark has taken it one step further with a limit of 2 ng/L of PFAS-4 in drinking water. The new drinking water quality criteria was implemented by the Danish Environmental Protection Agency already in 2021 after interpretation of The European Food and Safety Agency (EFSA) quality recommendations (Miljøstyrelsen, 2022). EFSA's latest risk assessment from 2020, recommends that the tolerable weekly intake of PFAS 4 is 4.4 ng/kg body weight. The risk assessment is based on epidemiological studies and effects on the immune system (Livsmedelsverket, 2022a).

Norrvatten's measurements of PFAS-4 in their waterwork have, in the last couple of years, oscillated between 5 ng/L and 3.6 ng/L which implies that with the new limits starting from 2026, it will be more challenging to distribute drinking water within the quality criteria (Norrvatten, 2023).

2.2 Landfills

2.2.1 Definition of a Landfill

According to 15 kap. 5 a § in Swedish legislation (SFS 1998:808. Miljöbalken) a landfill is a storage location for waste existing on or in the ground. A landfill is not a location where waste

1. is loaded to prepare it for onward transport to another location where it is to be processed,
2. is stored before it is recycled, if the storage takes place for a shorter period than three years, or
3. is stored before disposal, if the storage is for a shorter period than one year.

Furthermore, according to Avfall Sverige (2022), deposit of waste in a Swedish landfill is the final treatment option for waste which cannot be treated in any other manner in society today.

2.2.2 Classification of Different Types of Landfills

Swedish regulation, more precisely the 7 § ordinance (2001:512) states that landfills should be classified in one of the following groups: *landfill for hazardous waste, landfill for non-hazardous waste* or *landfill for inert waste*. Which means that they are classified depending on the waste types deposited on the landfill.

Hazardous waste is the description of a substance/s which conforms to certain criteria mentioned in the Swedish Waste ordinance (2020:614), such as for example waste from paint and lacquer remover. While a non-hazardous waste is a waste that is not considered hazardous but not either inert (Sparrenbom and Jeppson (red), 2022).
In 3 a § ordinance (2001:512), inert waste is defined as waste which *1.* does not undergo substantial physical, chemical or biological changes, dissolves, burns or reacts physically or chemically in any other way. *2.* does not decompose biologically or affects other materials with which it comes into contact with in a way that may cause damage to the environment or human health, and *3.* has a total leachability, a total pollutant content and an ecotoxicity of the leachate that is insignificant and does not endanger the quality of surface or groundwater Ordinance (2012:371).

At the same time, the guiding framework for the authorities in charge of supervising contaminated areas, known as the methodology for inventory framework (MIFO), expresses potentially contaminated areas in different branches and here landfills are divided into 3 different branch types, depending on the operation taking place at the location. These are (Naturvårdsverket, 2023b);

- *Waste landfills - non-hazardous, hazardous waste,*
- *Waste landfills - inert, excavated landfills*
- *Industrial landfills*

2.2.3 Management of Landfills in Sweden

All active landfills in Sweden today are covered by the Swedish ordinance (2001:512) on the landfill of waste, which entered into force in 2001 (SGI, 2014) as a result of the EU council directive (1999/31/EC) on the landfill of waste (Naturvårdsverket, 2023a). This ordinance poses certain requirements on landfills regarding for example collection of leachate water, protection measures under and around the landfills as well as for terminated (final) coverage (Naturvårdsverket, 2023a). The ordinance entry also resulted in the termination and final coverage of the majority of active landfills in the country (Avfall Sverige, 2022).

Furthermore, according to 14 § ordinance (2001:512), only waste that is treated is allowed to be deposited in a landfill. Treatment here refers to the use of chemical, physical, thermal or biological methods, including sorting of waste, which changes the characteristics of the waste, decreasing its mass or making it less dangerous, contributing to that handling is facilitated or recycling is promoted. Treatment is however not required for inert waste where treatment is not technically doable or for other waste where the treatment cannot decrease the negative effects on people's health or the environment.

2.2.3.1 Decommissioned Landfills

Today a few hundred landfills are active in Sweden and it is believed that there exist thousands of old decommissioned landfills (Naturvårdsverket, 2023a; SGI, 2023). However, hitherto a national compilation of decommissioned landfills is missing and the potential environmental risk they pose (SGI, 2023).

Landfills that were closed/decommissioned before the 16 of July in 2001 are not covered by the Swedish landfill ordinance (SFS 2001:512) (SGI, 2014). This implies that these landfills have closed down according to previous lower requirements or when no requirements for protective measurements existed. Thus, the environmental protection at these landfills may be lower than for the landfills in operation today. Additionally, it is common that limited or no monitoring of the leachate water from these landfills is executed (SGI, 2014).

Before more strict regulations on waste depositing were introduced, it was also common to deposit household waste which then included a variety of different waste types such as kitchen waste, latrine and sludge, furniture, bikes, medical residues, batteries, oil and paint residues and pesticides (Sparrenbom and Jeppson (red), 2022). Thus, it is likely that a cocktail mix of different pollutants exists in former household waste landfills. Including for example heavy metals such as Pb, Cd, Cu, Cr, Hg, Ni, Zn and minerals such as NH4-N and organic pollutants such as aromatic compounds (Sparrenbom and Jeppson (red), 2022).

2.2.3.2 Landfill Construction

Active landfills today are required to live up to certain construction standards, which must protect against groundwater intrusion and against leakage of leachate water through diversion and drainage (Naturvårdsverket, 2008). For example, the geological barrier under the landfill should be at least 0.5 metre thick while at the same time achieve specific permeability requirements depending on the landfill type, which is described more in detail in Naturvårdsverket (2004). Furthermore, a bottom sealing, drainage pipes and a drainage layer are required (Naturvårdsverket, 2004).

2.2.3.3 Final Coverage of Landfills

According to the Swedish landfill ordinance (SFS 2001:512), the final coverage of a landfill is a collective term for a permanent covering which can consist of a levelling layer, smoothing layer, sealing layer, drainage layer and protective layer.
Before a landfill undergoes final coverage, it is desired that the waste is as stable as possible, also meaning that the waste is decomposed as far as possible, and that the availability of water is limited. By that, the biological processes are stopped and the risk for future

formation of gas and depositions are minimised which can impair the function of the final coverage (SGI, 2011).

2.3.7 Landfill Phases

Waste deposited in landfills decomposes over time as it undergoes different chemical and biological processes. The processes can be linked to different phases in a landfill's existence. According to SGI (2011) the definition of phase separation and phase separation boundary may differ in different sources. However, in SGI (2011) it is suggested that 4 different key phases take place in the landfill composite: *An initial aerobic phase, an acidogenic phase, an acetogenic phase and an methanogenic phase*.

Which phase occurs when in a landfill can vary at different depths and depends on the conditions at different locations in the landfill. Parameters affecting the different chemical and biological reactions taking place in a landfill are, among other things, water access, availability of substrate (waste composition) for the active microorganisms driving the decomposition, compaction, temperature and pH. The characteristics of the leachate water and landfill gas, which are both resulting emission of landfill activity, are determined to large extent by the active phases occurring in the landfill (SGI, 2011).

2.2.4 Leachate Water

Leachate is by definition all water that has been in contact with landfill material and which is diverted from or detained in a landfill (Naturvårdsverket, 2008). It is primarily constituted by precipitation water which runs through the landfill, bringing along loose substances on its way (SGI, 2011). Leachate water can, however, also be produced from surface and groundwater that penetrates the landfill. This is often the case in older landfills (Naturvårdsverket, 2008)

The distribution pattern of leachate and the amounts produced depends on the location of the landfill and the hydrological conditions in the area. For example if a landfill is located in an inflow area (where precipitation can infiltrate in the soil), the soil is unsaturated and the leachate can infiltrate the soil, where some contaminants can be decomposed, while others reach the groundwater and risk contaminating it. The opposite conditions occur if the landfill is located in an outflow area, where the soil is saturated and the groundwater pressure avoids the leachate to escape which decreases contamination of the groundwater. However, in older landfills groundwater can penetrate the landfill which increases the leachate volumes (Naturvårdsverket, 2008). If an area is an inflow or outflow area depends on precipitation amounts and can vary over time and seasons (Sparrenbom and Jeppson (red), 2022).

SGI (2011) mentions the following factors as some of the most important when it comes to formation of leachate composition and volume.

- Waste types deposited on the landfill and its hydraulic capacity (Structure, hydraulic conductivity, capillarity, etc.)
- Landfill surface area
- Age of the landfill/progress phase/ decomposition state
- The wastes water content
- Precipitation amount
- Deposition technology
- Surface runoff and drainage which in turn is affected by any cover as well its permeability and possible occurrence of damage due to subsidence, erosion, etc.
- Presence of vegetation (affects evaporation)
- Topography/slope gradient

Leachate water produced is at certain landfills collected and transferred to local municipal sewage treatment plants. At others local treatment at the landfill site is performed. At old decommissioned landfills it is also common that no treatment of the leachate occurs at all (Naturvårdsverket, 2008).

2.2.4.1 PFAS and Leachate Water

Leachate water from landfills often has a complex chemical compensation and often holds a range of different PFAS, due to the many different PFAS available at the market and its wide use in products (Naturvårdsverket, 2023a).

Landfills and the resulting leachate water can become a point-source of PFAS to the environment due to different reasons. Some of the most common reasons are according to Hansson et al. (2016) that;

- the landfill can historically have deposited firefighting foam
- the landfill receives products consisting of PFAS

- the landfill deposit slag products from incineration plants
- final covering with and disposal of PFAS-containing sludge
- disposal of excavated material from contaminated areas
- landfill fires
- fire training area

Today there does not exist any general regulation of limited allowed PFAS content in leachate water released to water recipients and sewage treatment plants after local treatment. However, terms for this are decided for each individual landfill within the framework of the permit review (Naturvårdsverket, 2023a).

In the study performed by Miljösamverkan Sverige (2022), all of the collected data from 117 landfills (all around Sweden) detected PFAS in the leakage water. Additionally, this compilation study showed that higher levels of PFAS were detected in groundwater compared to surface water samples and that the collected data showed a tendency for higher levels of PFAS in leachate water from active landfills compared to landfills in other phases.

Furthermore, a compilation study of PFAS-levels in leakage water from Swedish waste facilities and landfills has been performed by Avfall Sverige, which shows that the average level of PFOS in leakage water is 120 ng/L and in some cases as high as 10 000 ng/L. According to the same study it is suggested that the average level of many PFAS (24 different where included in the study) in leachate water is around 1000 ng/L (Avfall Sverige, 2018).

In the literature review performed by Zhang et al. (2022), it is suggested that a new trend seems to be emerging of the composition of PFAS in landfills (solid waste), showing a change from long-chain PFAS to shorter-chain PFAS. Based on the collected information by Zhang et al. (2022) it also appears to be a dominance of PFAS chains with 4 to 7 carbon atoms in landfill leachate. Furthermore, also Sparrenbom and Jeppson (red) (2022), state that it is common that the leachate consists of proportionally more short chain PFAS than long chained, as these are mobile in water and soil.
So far, no correlation between type of waste landfilled and PFAS concentrations in leachate has been identified according to Zhang et al. (2022).

2.3 Principal Component Analysis

Principal component analysis (PCA) is a multivariate statistics method. Its core purpose is to reduce interrelated variables in a large data set (reduce the dimensionality) by transformation to a new data set with fewer variables, known as principal components (PCs), while keeping as much of the variation present in the initial data set (Jolliffe, 1986).

To produce these new PCs which are uncorrelated, the weighted sum, also called the linear combinations, of the variables in the initial data set are calculated (Jolliffe, 1986). A rotation is also included in the transformation to create a new coordinate system using the PCs as axes. The rotation maximises the variation in the first PC. The second PC which is perpendicular to the first, tries to present the remaining variation as much as possible and so the variance continuously decreases for the remaining principal components, which all are perpendicular to each other. Hence, the first few PCs can be used to present the data, keeping most variation from the initial data set, in a more interpretable manner (Naturvårdsverket, n.d.).

PCA is commonly used to find patterns such as correlations, clusters or outliers in a large dataset (Naturvårdsverket, n.d.). It can also be used for fingerprinting and source tracing of contaminants such as PFAS, as in the case of Sörengård et al. (2022).

3. Materials and Methodology

3.1 Data Collection

3.1.1 Landfills Within Östra Mälaren Water Protection Area

Identification and characterisation of active and inactive landfills within the water protection area named Östra Mälaren began by collecting secondary data from literature and authorities' databases. Both qualitative and quantitative data was collected, examples of information retrieved can be seen in Table 3.

Table 3. Data collected about the identified landfills within Östra Mälarens water protection area.

Qualitative data about the landfills (examples)	● Geographic location ● Geological conditions ● Supervisory authority ● Material content of the landfill ● Active or inactive landfill
Quantitative data about the landfills (examples)	● Surface area ● Coordinates of location (SWEREF 99 TM) ● Landfill age

Certain data was retrieved from data sets created by Ekerö, Stockholm and Järfälla municipality. These data sets were available at a non-public web platform (Stockholm Stads sharepoint) created for the project "Fokus på PFAS i Östra Mälarens vattenskyddsområde" initiated by Norrvatten and Stockholm Vatten och Avfall.

Data sets concerning landfills in the eastern Mälaren region were also retrieved via email correspondence with employees at Ekerö, Järfälla, Stockholm and Upplands-Bro municipalities. In the web version of the EBH database map (Länsstyrelsen Stockholm, 2023), 123 objects were categorised as either waste landfills (non-hazardou/hazardous waste), waste landfills (inert/excavated landfills) or as industrial landfills. In the filtering process resulting in these 123 objects, only the primary branch was included and objects within the following municipalities; Huddinge, Ekerö, Upplands-Bro, Stockholm, Järfälla, Salem and

Botkyrka. More specific information about these 123 objects was also received from the Stockholm County Administrative Board via email (EBH, 2023).

With the help of VISS-water map (VISS-water map, 2023) and the coordinates given by the documents available by EBH (2023) it was possible to determine which of these 123 objects are located within the Östra Mälaren water protection area. The sites outside of the water protection area were not selected to be a part of this study.

Data about the Högbytorp facility and measured PFAS levels, were also accessed through personal communication (e-mail) with employees at Ragn-Sells.

Databases used to collect secondary quantitative and qualitative data about landfills in the Östra Mälaren region are presented below:
EBH-database, EBH-map, VISS- water map (vattenkartan), lantmäteriets - my map (min karta), SGU map viewer, Google Scholar, Scopus, Primo (KTH's own search platform)

3.1.2 Landfills in Focus

Of the identified landfills within the Östra Mälaren water protection area, three different landfill localities were chosen for more in depth analysis. These three were Skå, Svartsjö and Johannelund, where sampling and measurements were already planned within the previously mentioned project "Focus on PFAS in Östra Mälaren water protection area". Within this project, initiated by Norrvatten and Stockholm Vatten och Avfall specific prioritised areas were chosen for further investigation concerning PFAS sources by the participating municipalities in the project. The selection of sampling sites was based on catchment areas with connections to activities that could potentially be a source of PFAS leakage.
The focus was to investigate all types of potential point sources of PFAS, however, sampling was among other places chosen in connection to the three focused landfills in this thesis. Ekerö municipality prioritised, for example, Svartsjö landfill as potential point source of PFAS as its located within the catchment area named Hilleshögviken, where the levels of PFOS is exceeding the quality levels, as stated by VISS (2023), and which discharge reaches Mälaren-Görväln. Ekerö municipality, also prioritised Skå, as PFAS has earlier been detected at the site and as the operations taken place at the site are suspected to constitute sources of PFAS contamination, for example the site has been used for firefighting testing. Furthermore,

Stockholm Stad selected Johannelund landfill as prioritised sampling site as PFAS has earlier been detected in the groundwater within the catchment area of Råcksta träsk which discharge also reach Mälaren-Görväln.

Also, Högbytorp landfill, which is located outside of the water protection area, but whose water discharge reaches Mälaren-Görväln water body, was also selected for further analysis as Ragn-Sells gave the author access to their multiannual control program at two locations, one upstream and the other one downstream of the landfill area.

Information about these four landfills localities is presented in Table 4 and in the 4 subsections below.

Table 4. The four landfill localities in focus and related information.

Attributes	**Skå**	**Svartsjö**	**Johannelund**	**Högbytorp**
Connected sampling locations	EYV2301, EYV2302	EY2308	SYV2305, SYV23059	RY202, Y208, Brobäcken
Municipality	Ekerö	Ekerö	Stockholm	Upplands-Bro
Coordinates (SWEREF99 TM North,East)	6580788, 655240	6583489, 655862	6585112, 661920	6603815, 648092 (Landfill 2)
Type	Waste landfill- non-hazardous, hazardous waste	Waste landfill- non-hazardous, hazardous waste	Waste landfill- non-hazardous, hazardous waste	Waste landfill- non-hazardous, hazardous waste
Area [m2]	14 817	Own estimation: 6502	100 000 (Svenson et al., 2001)	∑ 3 separate landfills = 676 000

Content	Household waste mixed with sewage sludge and latrine	Household and industrial waste	Storage of excavation masses during its active period. It was covered with soil and in some parts trees were planted.	Landfill 1: Many different types of waste. Landfill 2: Mainly ash. Landfill 3: Mainly contaminated soil
Land use (own interpretation)	Arable land/industrial area	Arable land	Urban area/industrial area	Open land/Industrial area
Age	1975-1985; 1991-1998	Unknown. However, has not been in use for 50 years	Start 1965- unknown	Landfill 1: 1964-2008 Landfill 2: 2002- Landfill 3: 1998 -
Operation status	inactive	inactive	inactive	inactive/active
Officially covered	Yes in 2015	unknown	no	no
Partiel catchment area (DARO)	Mälaren - långtarmen (VISS)	Mälaren -Hilleshögviken (VISS)	Utloppet av Råcksta Träsk, Mälaren Görväln, Mälaren-Ulvsundasjön (VISS)	Mälaren-Görväln (VISS)

Below in the following four subsections other important information related to the landfills in focus are presented.

3.1.2.1 Skå

Skå landfill is located within a larger waste facility area. The whole landfill area is around 4 ha, while the landfill itself is about 14817 m2 (Ekerö Municipality, 2023). Near north of the landfill a recycling centre (ÅVC) is located. Today sewage sludge is temporarily stored at a facility located west of Skå ÅVC and Skå landfill. The process water from this temporarily storage is lead to the so called "inre diket" and from there further lead to Skå landfills leachate water pond (southwest of the landfill area). No information about what happens with leachate water in the water pond after accumulation has been found. The facility area has also previously been used as a firefighting testing site.

The operation takes place on arable land which is owned by the municipality. East of the landfill area farmland occupies the land and also a smaller industry area (Ekerö Municipality, 2023).

Some parts of the ÅVC are within another catchment area (Mälaren-Hilleshögviken). The landfill area is within Mälaren-långtarmen catchment area (VISS-my map, 2023).
During a 10-year period household waste mixed with sewage sludge and latrine was deposited on the landfill (Ekerö Municipality, 2023).

The landfill is today considered inactive. Its operation began in Januari 1975 and stopped in 1985. However, between 1991-1998 dehydrated sewage sludge was deposited in the landfill The final covering of the landfill started and finished in 2013. The covering was also approved by Länsstyrelsen in 2015 (Ekerö Municipality, 2023).

According to Ekerö municipality (2023), the landfill land is slightly inclined towards the southwest, similar to the believed groundwater flow direction. A pictures of the landfill area and a map of the landfill surrounding and the sample sites in connection to the landfill are seen in Figure 2.

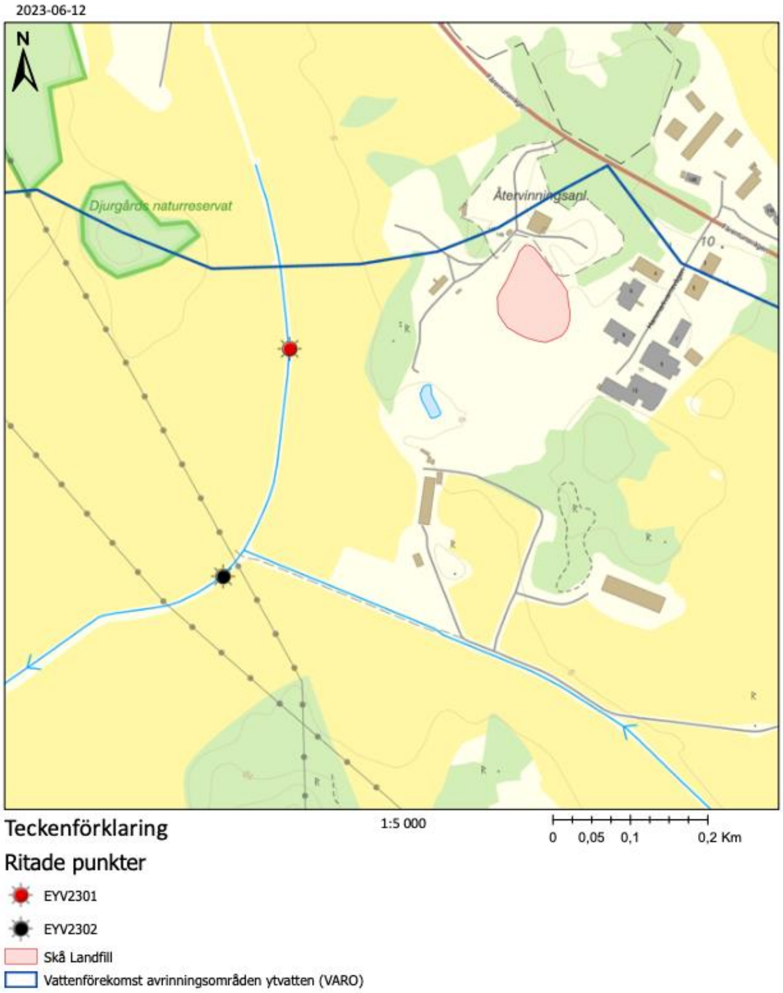

Figure 2. The top picture where the landfill area is calculated and illustrated has been accessed from personal communication with Ekerö municipality (2023). The scale of the map is not known. The bottom map has been accessed and modified within the VISS water map (2023). It shows the division border of the catchment areas (dark blue line) and the sampled surface water (light blue) together with the locations of the taken surface water samples (EYV2301 and EYV2302) linked to Skå landfill.

3.1.2.2 Svartsjö

Svatsjö landfill is located in a small grove surrounded by arable land (observations during the field study). The area of the landfill was not found during data collection and thus it was estimated with the help of Lantmäteriets my map (2023a), where it was possible to create a polygon calculating the marked polygon area. The created polygon area was assumed by looking at SGUs map viewer (Soil types 1:25000 - 1:100000) (SGU, 2023), which shows a form in the landscape which has been classified as an “artificial fill” which according to SGU (2021) is soil or other masses inflicted by humans.

According to (EBH, 2023) Svartsjö has been used as a general landfill for the Svartsjö parnish, containing a mix of household and industrial waste. When the depositing of waste started seems unknown, or at least no information about it could be found. However, according to EBH (2023) no depositing of waste has occurred during the last 50 years, except when illegal tipping occurred in 1989.

In general not much information about Svartsjö landfill could be found in literature or in the authorities databases. In Figure 3, a map of the area surrounding the landfill, and the sample sites are illustrated. Furthermore, the estimated landfill area is visualised in the bottom picture in Figure 3.

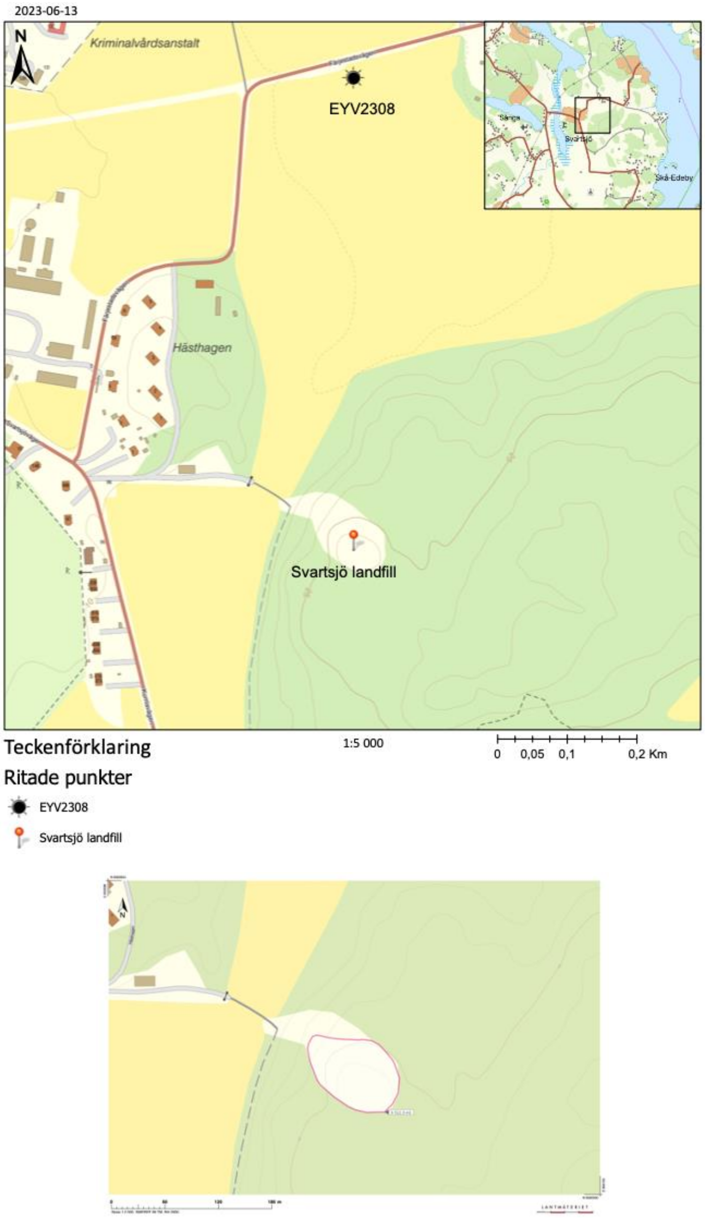

Figure 3. In the upper map the sampling site in connection to Svartsjö landfill (EYV2308) is visualised. The sample was taken in an arable ditch. The bottom map illustrates the created polygon estimating the landfill area in lantmäteriets-my map (2023a) which was based on the form shown in the SGUs map viewer (Soil types 1:25000 - 1:100000) that was classified as an "artificial fill" (SGU, 2023).

3.1.2.3 Johannelund

Johannelund is located in an urban area close to an industrial ground (Vinsta), located north and east of the landfill. The urban area comprises a large network of storm water pipes from which the field samples were collected (see Figure 4). There are several locations within the industry area where fire extinguishing foam has been used (Rosenqvist, 2020).

During its active period (1965 -unknown) storage of excavation masses occurred at the landfill (EBH, 2023). At some point it was covered with soil and in some parts trees were planted. In 1995 the surface was covered by dense vegetation (Svenson et al., 2001). According to EBH (2023), it has not been formally decommissioned or covered. Instead, a simple soil covering has been performed (SVOA, 2021).

Johannelund is a surface water divider, linked to three different partiel water catchment areas (seen in Figure 4) (VISS-water map, 2023).

Overall, not much information about the landfills content or administrative details have been found in literature or in the database research.

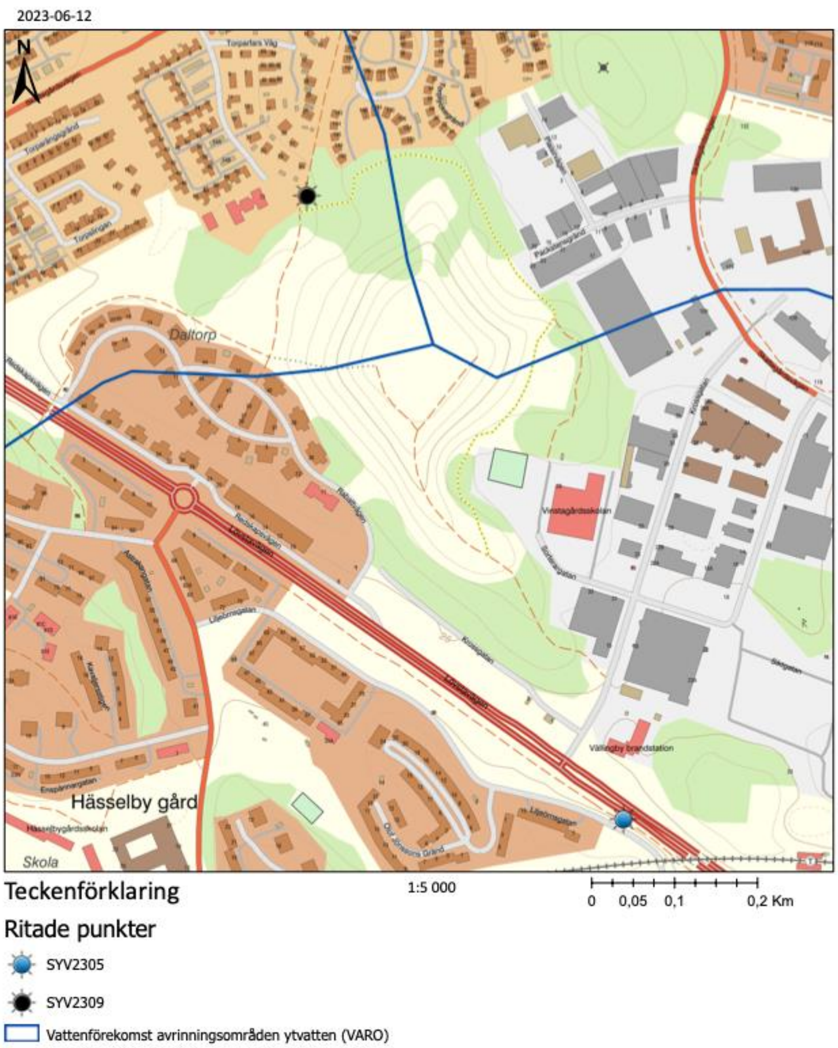

Figure 4. The map shows Johannelund landfill and this study's two sample locations (the blue and black dot), SYV2305 (by the road in, south-east of the landfill) and SYV2309 (north-west of the landfill). The picture was accessed and modified within the VISS-water map (2023). Furthermore, the

dark blue line illustrates the division between the three partiel water catchment areas. The south part is connected to the catchment area "the outlet of Råcksta träsk". The upper-left to "Mälaren-Görväln"and the upper-right to "Mälaren- Ulvsundasjön". The two field samples taken in this study in connection to the landfill, SYV2305 and SYV2309, are located within the catchment areas "the outlet of Råcksta träsk" and "Mälaren-Görväln" respectively

3.1.2.4. Högbytorp

Högbytorp is located outside of the Östra Mälaren water protection area, however, the facility discharge ends up in Mälaren-Görväln water catchment area (VISS-water map, 2023). The waste handling at Högbytorp began in 1964 and the facility is owned by the company Ragn-Sells[1]. The whole facility of Högbytorp incorporates not only landfills but many forms of waste handling activities such as reception, intermediate storage, treatment, and recycling. Hence, many types of waste enter the facility (i.e., ash, sludge, contaminated soils, electronics, household waste and waste products from the pharmaceutical industry). In 2022, Högbytorp received in all 1640 839 tons of waste (Ragn-Sells, 2022).
Three landfills exist at Högbytorp. Their centre points at the facility are seen in the left map in Figure 5. In Table 5. more information about the three different landfills is presented.

Table 5. Information (numbers from 2021) about the three existing landfills at Högbytorp[2].

	Landfill 1	**Landfill 2**	**Landfill 3**
Approximate centre point (SWEREF 99 TM N,E)	6603199, 648448	6603815, 648092	6604148, 647506
Content	Many different types of waste including (i.e. colour waste)	Mainly ash	Mainly contaminated soils
Landfill type	Non- hazardous waste	Hazardous waste	Non- hazardous waste
Area	27, 4 ha	13,8 ha	26,4 ha
Covered area	27,4 ha	6,8 ha	7,9 ha
Depositing start	1964-65	1998	2002

[1] Ragn-Sells, Högbytorp, 2023, Meeting with Norrvatten, Ragn-Sells presentation (7 February)
[2] Eva Bivall, Head of the facility development at Högbytorp, 2023, email (20 February)

Depositing end	2008	Ongoing	Ongoing
Additional information		Closed leachate system	

Different types of water flows are generated at Högbytorp. All contaminated waters are treated on site and some are thereafter also treated in an external sewage treatment plant (Käppala). Surface water and groundwater in the facility area flows either towards Sätrabäcken in the east or to Önstabäcken in the west, which indicates that stormwater or water runoff from the landfill covers reaches one of these streams that later merge into Brobäcken (Ragn-Sells, 2022) which is illustrated in the right map in Figure 5.

Leachate generated from landfill 1 (*non hazardous waste*) is collected and transported to a pound system after undergoing a treatment to reduce the amount of nitrogen and metals. The pound system functions as further treatment (sedimentation) of the leachate and as a storage before the treated leachate is pumped to soil-plant systems in the vicinity of the waste facility (Ragn-Sells, 2022)

The leachate produced from landfill 2 (*hazardous waste*) is collected in a closed system, where the generated leachate is used in the treatment process for ash to be deposited. Thus, according to Ragn-Sells no surplus leachate is produced from landfill 2.

Leachate from landfill 3 *(non hazardous waste*) is also collected and stored in leachate pounds. The leachate is then treated in the same system as the leachate from landfill 1 (ending up in the soil-plant system) or is used for irrigation at the landfill area, or is linked to the processes in landfill area 2 if needed.

Irrigation of treated leachate water at the soil-plant bed system usually starts in April and ends in August or September. This has shown that larger levels of PFAS are detected in downstream samples during the irrigation period compared to when no irrigation occurs (Ragn-Sells, 2022).

Cleaning of PFAS in leachate water generated at the facility has been applied in full scale in 2021 and 2022, using carbon filter techniques. According to Ragn-Sells (2022) around one third of the PFAS present in the leachate could be separated (better separation of long-chain PFAS). However, the cleaning technique has shown to be very expensive, up to several thousand SEK per separated gram PFAS. Ragn-Sells prevent PFAS from reaching the environment in other ways as well, above all by directing PFAS-containing waste to the landfill area 2, where the closed leachate system exists.[3]

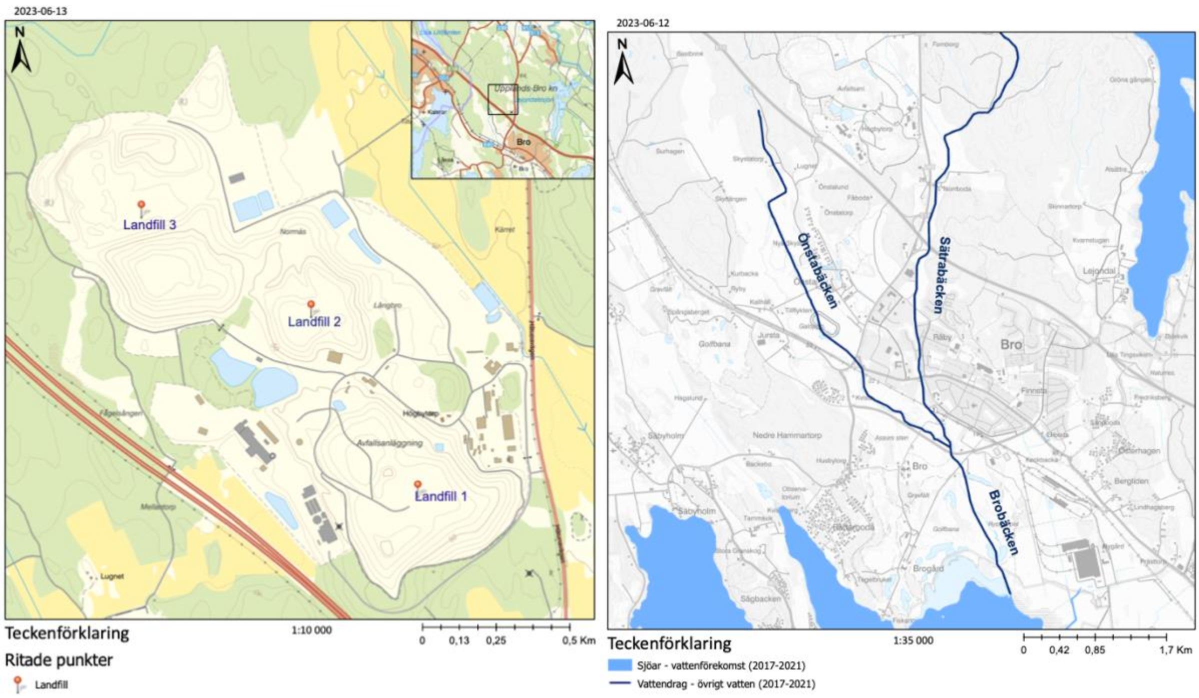

Figure 5. The left map shows Högbytorp facility (VISS water map, 2023) and the three landfills centre points marked with an orange pin. Landfill 1 is located by the lowest laying pin. Landfill 2 by the middle pin and Landfill 3 by the highest laying pin. The right map (edited including water course names) from VISS water map (2023) illustrates how sätrabäcken and Önstabäcken merge into Brobäcken which flows out towards Mälaren-Görvaln water body.

[3] Ragn-Sells, Högbytorp, 2023, Meeting with Norrvatten, Ragn-Sells presentation (7 February)

3.1.4 Field Sampling and Measurements

To collect primary quantitative data of PFAS and basic water chemistry levels in relation to the presence of landfills, field sampling and measurements were carried out. The field work incorporated both sampling for PFAS and basic water chemistry as well as direct measurements of physico-chemistry parameters and water flow where possible. Only surface water samples were taken. Groundwater and soil sampling of PFAS was not included due to the scope of the study. Field sampling and measurements were taken on two different occasions. One on the 8th of February (2023) where only one sampling point in Brobäcken was measured. The other occasion was during week 12 (20-21 March 2023) where measurements were collected nearby three different landfills; Skå landfill, Svartsjö landfill and Johannelund landfill. The aim was to take samples upstream and downstream of these landfills to be able to estimate the landfills influence of PFAS released to the surface water, which however, proved to be difficult to realise as some landfills are water flow dividers (such as Johannelund) and as it was considered that no suitable upstream surface water sampling locations existed by Skå and Svartsjö). In Table 6, the sample locations names (also used in the project "Focus on PFAS in Östra Mälaren water protection area") and information about each sampling location and its geographical relation to the landfill are among other things presented.

Table 6. Further information about where the field samples were collected.

Sample name	*Sample Date*	*Coordinates SWEREF99 TM (North, East)*	*Municipality*	*Type of water sample*	*Water flow measure-ment*	*The geographical relation to the specified landfill.*
Brobäcken	08-02-2023	6598189, 649783	Upplands-Bro	Surface water stream	yes	Outlet to Mälaren-Görväln water body and further downstream of several PFAS realising sources, including Högbytorp waste facility (VISS water map, 2023; Ragn-Sells, 2022)
EYV2301	20-03-2023	6580736, 654933	Ekerö	Surface water stream	yes	Downstream Skå, but located higher up than EY2302
EYV2302	20-03-	6580442, 654847	Ekerö	Surface	yes	Downstream Skå

	2023			water stream		
EYV2308	20-03-2023	6584105, 655878	Ekerö	Surface water stream	yes	Downstream Svartsjö
SYV2305	21-03-2023	6584564, 662175	Stockholm	Storm water well	no	Downstream Johannelund
SYV2309	21-03-2023	6585317, 661793	Stockholm	Storm water well	no	Downstream Johannelund

3.1.4.1Water Sampling and Measurement Procedure and Laboratory Analysis

At all sampling locations presented in Table 6, PFAS (24 PFAS targeted, see Appendix E) and basic water chemistry variables (Appendix E) were sampled. Also pH, dissolved oxygen, conductivity and water temperature was measured with a HQ series Multi (Hach) instrument at each location. Total organic carbon (TOC) was sampled separately for at the sample locations visited in week 12. The number of samples taken at each location and where the samples were sent to laboratory analysis can be seen in Table 7.

Table 7. The samples collected at each location including information about the sampling bottles, collected water volumes and where the samples were sent to analysis.

	PFAS sample	**Water chemistry sample**	**TOC sample**
Brobäcken	2* 250 ml plastic bottles (topped up) sent to Eurofins for analysis	1*100 mL PE plastic bottle (topped up) sent to SLU for analysis	
EYV2301	3* 250 ml PE-HD plastic bottles (topped up). Sent to ALS global for analysis	2*250 ml plastic bottles (topped up). Sent to ALS global for analysis	1* 500 ml plastic bottle (filled to 80%). Sent to Norrvatten for analysis
EYV2302	3*250 ml PE-HD plastic bottles (topped up). Sent to ALS global for analysis	2*250 ml plastic bottles (topped up). Sent to ALS global for analysis	1*500 ml plastic bottle (filled to 80%). Sent to Norrvatten for analysis
EYV2308	3*250 ml PE-HD plastic bottles (topped up). Sent to ALS global for analysis	2*250 ml plastic bottles (topped up). Sent to ALS global for analysis	1*500 ml plastic bottle (filled to 80%). Sent to Norrvatten for analysis

SYV2305	3* 250 ml PE-HD plastic bottles (topped up). Sent to ALS global for analysis	2 *250 ml plastic bottles (topped up). Sent to ALS global for analysis	1*500 ml plastic bottle (filled to 80%). Sent to Norrvatten for analysis
SYV2309	3* 250 ml PE-HD plastic bottles (topped up). Sent to ALS global for analysis	2* 250 ml plastic bottles (topped up). Sent to ALS global for analysis	1*500 ml plastic bottle (filled to 80%). Sent to Norrvatten for analysis

Plastic gloves were used at all times, when handling the equipment and water samples. The water sample bottles were rinsed 3 times (at field occasion during week 12, the bottles were only rinsed 1 time, due to limited time) with the stream water to get rid of unwanted content in from the bottles that could disturb the analysis. Each sample bottle was marked with sample location, date and sample type. After collecting the samples they were stored in a field cooling box (not frozen). The water chemistry samples taken in week 12 were delivered to the laboratory (ALS Global) the same day they were collected (time sensitive analysis). The TOC samples taken during week 12 were stored in one of Norvatten's fridges at the end of the sampling day, before being analysed. The other samples (PFAS) were after the sampling day stored in a freezer (around -18 deg. C), before being sent to the laboratory for analysis.

In SYV2305 and SYV2309, sampling occurred in storm water wells. These were the two sampling locations nearby Johannelund landfill. With the use of a peristaltic pump (12 VDC Eijkelkamp) and a plastic tube taped to an extendable rod water could be collected. The plastic tube was changed at each sampling location to avoid cross contamination between sites. Conductivity, pH, dissolved oxygen and temperature was measured in continuously flow-through pumped up water collected in a plastic cup. While measuring conductivity the cup was slightly stirred.

In Appendix B, the field equipment used during field sampling is presented.

3.1.4.2 Measurements of the Water Flow at the Sample Locations

To estimate the water flow by the sampling locations (excluding the storm water wells, SYV2305 and SYV2309) the so-called "orange method" was used based on the method descriptions in Bydén et al. (2003). First a measurement tape was laid along the water stream. Thereafter an orange was put in the stream and the time it took for the orange to travel one point to another along the measuring tape was measured. The time it took for the orange to travel at the water surface was measured 4-6 times. With these time and distance measurements the velocity (V_{max}) of the water flow could be estimated. The water course cross-sectional area (A) was then calculated from measurements using a folding rule. First the depth was measured thereafter the width of the water course. The flow of the water stream (Q) was then evaluated based on the measured area and velocity. As the watercourse is slowed down by the bottom conditions, the area and velocity were also multiplied with a factor dependent on the bottom conditions (k). According to Bydén et al. (2003) the factor k used should be based on the following numbers and conditions at the bottom:

k=0.5 if the bottom is very uneven, with rocks and/or reeds and grass
k=0.6 if the bottom is somewhat uneven with rocks
k=0.7 if the bottom is even with sand or gravel
k=0.8 if the bottom is even artificial construction of tree, steel or concrete

The following was the formula used to estimate the water flow (Bydén et al., 2003):

$$Q = A \cdot V_{max} \cdot k$$

The measured water flows have some inherent uncertainty as the orange used for determining the speed of the water was sometimes delayed by vegetation or branches. Furthermore, the watercourse cross-sectional area was difficult to measure as the area size and shape was not consistent along the water course.

3.2 Calculations of Leachate and PFAS Load

3.2.1 Estimations of Leachate Discharge

To evaluate the mass flow of PFAS coming from the landfills, an estimate of the leachate discharge from the landfill is required.
To estimate the leachate discharge from the landfills the water balance from Sparrenbom and Jeppson (red) (2022) was used, assuming that all water that has been in contact with the landfill area can be considered leachate (i.e., both runoff and infiltrating water).

The water balance adopted from Sparrenbom and Jeppson (red) (2022):

$$Q_{out}\ [\frac{m^3}{year}] = (P + ET)\ [\frac{mm}{year}]\ \cdot 0.001\ \cdot\ A\ [m^2]\ +\ Q_{in}\ [\frac{m^3}{year}]\ \pm \triangle\ M\ [\frac{m^3}{year}]$$

Here the Q_{out} stands for the sum of the outflow of water from the landfill area, including both the surface and groundwater discharge. P and ET are the abbreviations for precipitation and evapotranspiration respectively. A stands for the area of the landfill and Q_{in} is the flow of water coming into the area of the landfill from the surrounding. The change of the water reservoir of the specific area over the time period in focus is the $\triangle M$. As Q_{out} is expressed in $[\frac{m^3}{year}]$, $\triangle M$ were considered 0 as it is assumed that after one year all water in the landfill reservoir has been exchanged. Furthermore, Q_{in} was also considered 0, for the sake of simplicity and as zero values of this factor was stated in the downloaded data from SMHI.

All precipitation and evapotranspiration data used in the water discharge calculations were collected from the generated results of SMHIs S-HYPE (Sweden- Hydrological Predictions for the Environment) model for the specific partiel catchment area (DARO) in focus (determined with the help of the VISS water map (2023)).

The landfills surface areas were collected through either the EBH database or the municipalities which shared information at the previously mentioned non-public web platform within the project “Focus on PFAS in Östra Mälarens water protection area”. The area of Svartsjö landfill was estimated as described in section *3.1.2.2 Svartsjö*.

3.2.2 Estimated Load of PFAS per Year

3.2.2.1 Method 1- The Mass flow Estimated at the Sampling Locations

Mass flow [kg/year] of PFAS from the sample location (EYV2301, EYV2302, EYV2308, Brobäcken) was estimated by Equation 1. As no concentration and water flows have been measured at the locations earlier it was assumed that the measured PFAS concentrations and the water flow can be applied to every day during the whole year (rough assumption). SYV2305 and SYV2309 were not included in these mass flow estimations as no water flow was measured at these sample occasions.

Equation 1:

$$Mass\ flow\ =\ x \cdot\ Q\ \cdot 10^{-9} \cdot (3600 \cdot\ 24 \cdot 365)$$

$$x =\ Measured\ concentration\ of\ PFAS\ [ng/l]$$
$$Q\ =\ Estimated\ water\ flow\ at\ the\ sample\ location\ [m^3/s]$$
$$Mass\ flow\ =\ [kg/year]$$

The mass flow of PFAS at Högbytorps sampling spot, Y208, has been calculated differently as PFAS and water flow measurements have been taken repeatedly during the last couple of years (data accessed from Ragn-Sells). It should be noted that the majority of the PFAS samples measured at Y208 (in all n=8) between 2019-2022 were collected during or right after the season or leachate irrigation at the soil-plant bed systems (April-September). Mass flow of PFAS at Y208 was estimated by Equation 2. It was decided that it would follow the same calculation method used by Ragn-Sells (Rang-Sells, 2022; [4]) where a yearly average mass is calculated based on PFAS levels and water flows which has been measured between 2019 to 2022. The method considers existing measurements of PFAS levels in the month in which measurements have been collected and assumes that that value (the single measurement of PFAS in the month) can be applied for the whole month. The assumed PFAS

[4] Lovisa Sjernman, Environmental Analyst at Högbytorp, 2023, email (Continuous contact during Mars, April and May)

level is then multiplied with that month's total flow. Then an average of the assumed monthly amounts of PFAS are multiplied with 12 to obtain an average annual amount of PFAS

Equation 2:

$$Mass\ flow\ = \frac{\sum_{i=month}^{n} (\ x_i\ \cdot \bar{Q}_i\ )}{n} \cdot 10^{-12} \cdot 12$$

$$x\ =\ Measured\ concentration\ of\ PFAS\ [ng/]$$
$$\bar{Q} =\ Average\ measured\ water\ flow\ per\ month\ [l]$$
$$i\ =\ The\ single\ monthly\ measurement$$
$$n\ =\ The\ number\ of\ single\ monthly\ measurements$$
$$Mass\ flow\ =\ [kg/year]$$

3.2.2.2 Method 2- The Load Estimated from the Landfills Using the Calculated Leachate Discharge

To try to estimate the mass of PFAS flowing from the focused landfills, it is assumed that the measured PFAS concentrations at the sampling locations (downstream the landfills) can be applied to the roughly estimated leachate discharge (see section 3.2.1 Estimations of Leachate Discharge) from the landfills.

Equation 3:

$$Mass\ flow\ \ = x \cdot L \cdot 10^{-9}$$

$$x =\ measured\ concentration\ of\ PFAS\ \ [ng/l]\ at\ the\ sampling\ spot\ (downstream\ the\ landfill)$$
$$L\ =\ Estimated\ leachate\ discharge\ [m3/year]\ from\ the\ landfill$$
$$Mass\ flow\ =\ Estimated\ mass\ of\ PFAS\ \ in\ the\ \ annual\ leachate\ discharge\ (kg/year)$$

As Johannelund landfill is a surface water divider, both SYV2309 and SYV2305 were considered downstream sample locations and thus measured PFAS concentrations from both these locations were used to estimate the mass load generated from Johannelund landfill with method 2. However, it was roughly assumed that two quarters of the estimated leachate discharge would enter the catchment area “Outlet of Råcksta träsk” (i.e., flowing towards SYV2305) and that one quarter would flow to “Mälaren-Görväln"catchment area where

SYV2309 is located. The simplified proportion of the leachate discharge load was based on the VISS my map seen in Figure 5 (section 3.1.2.3 Johannelund).

3.4 Data Analysis

3.4.1 Statistical Analysis

For the statistical analysis of PFAS, all concentrations expressed as less than (<) the reporting limit value (LOR) in the laboratory analysis result were excluded. However, it should be noted that some values expressed after the less than sign (<) were higher than the LOR suggested by the ALS globals analysis certificate (see Appendix E).

3.4.1.1 Principal Component Analysis (PCA) in IBM SPSS Statistics and in PAST4

While PCA often is used as a statistical method for determining trends and patterns of large data sets (Jolliffe, 1986), in this thesis project rather used a clustering method, for the small data set available for analysis. The PCA tool has been used to visualise similarities and dissimilarities of the data collected in a two-dimensional space to facilitate identification of clusters and has also in this manner, attempted to be used for source tracing of PFAS.

In this study two different PCAs have been performed including different data inputs and with different purposes. To interpret the result for the PCA, loading plots and biplots were used. Also, two different programs have been used to perform PCA of the collected data. IBM SPSS Statistics is a statistical software program that has been used to perform the first PCA of the water chemistry data collected in the study. This program was chosen as it was the only statistical program that students could download as a KTH-licensed software. The other program used was PAST4, a freely available statistical software created at the University of Oslo. It is a specialised program for multivariate analysis and was one of the statistical software's suggested for PCA as communicated by Naturvårdsverket (n.d). PAST4 was used to generate a second PCA based on data of PFAS levels in different samples as it was easier to use in comparison to SPSS and as it could smoothly display the observations (samples) and the variables (individual PFAS) in a biplot.

The first PCA (PCA **A**) was performed to investigate similarity or dissimilarity of the water composition at different sampling sites and in comparison with other external water types. The water chemistry parameter measured at each sample location in this study was subjected to the PCA, together with other collected data sets found in the literature, such as the water chemical variables measured in a leachate sample, and in the raw water extracted by

Norrvatten (median of samples taken between 2000 to 2020). Also accessible water chemical data from the upstream and downstream samples at Högbytorp from mars 2022 (around the same time of the year as this study's sampling) were included. See Appendix C Table 11, for information about the water chemical variables included in the analysis and which literature sources the data sets were collected from.

The second PCA (PCA **B**) was carried out to see if the variance of the PFAS concentrations detected in each sample could indicate any clustering among the different samples. PFAS data from other sampling sources (not the field samples in this study), were also included to enable source tracing of the detected PFAS. These external sampling sources included the raw water extracted by Norrvatten, a leachate sample, sewage water and precipitation. The data used as input and its literature sources are presented in Appendix C Table 12. Furthermore, all assumptions made for generating the PCA can be seen in Appendix A.

Overall, the limiting data set, included in PCA **A** and PCA **B**, have made it difficult for the analysis to achieve certain criterions which is considered appropriate to satisfy for valid PCA results. However, both PCAs were included in the thesis as they can represent indications of results. Addition of more observation data in the PCAs can help to verify or reject the statistical analysis.

Both PCAs were based on a correlation matrix. For PCA **A**, the correlation matrix in SPSS was positive semidefinite which also was the case for PCA **B** in PAST4 (positive determinant). Furthermore, the direct oblimin rotation was selected for the PCA generated in SPSS.
According to Jolliffe (1986), one criterion for a valid PCA results, is that two selected PCs for visual description of the data should have cumulative percentage of total variance exceeding 80%. In PCA **A**, two PCs were extracted with a cumulative percentage of total variance at 89%. For PCA **B**, also two PCs were selected for visual interpretation, however, their cumulative percentage of the total variance reached 79.5%.
For both PCAs, however, the two retained PCs had eigenvalues (the total amount of variance) > 0.7 as suggested by Jolliffe (1986).
Measure of sampling adequacy also called the *Kaiser-Meyer-Olkin* (KMO) measure can furthermore, be used as a criterion for PCA based on a correlation matrix. For PCA **A** and

PCA **B**, the KMO was 0.69 and 0.31 respectively. A KMO under 0.50 is often considered unacceptable (IBM, 2023).

3.4.2 QGIS

QGIS is a free and available geographical information system program which can be used for many different applications. In this study QGIS (Version 3.28 Firenze) has been utilised to identify which of the landfills collected during data research that area located within Östra Mälarens water protection area and where these landfills are located in relation to each other and to Görvälnverket. It has also been used for storing collected landfill information in layers attribute tables. The landfills coordinates have been used as input data together with base layers of catchment areas (collected from the County Administrative Boards' geo catalogue (2023)), terrain layers (downloaded from SLU's geodatabase (2023)) and the layer illustrating Östra Mälaren water protection area from non-public web platform within the project "Focus on PFAS in Östra Mälarens water protection area" . In this study SWEREF 99 TM, has been set to the coordinate reference system in QGIS. While collecting data of landfills, the coordinates of the landfills location has sometimes been expressed in other coordinate systems than SWEREF 99 TM. In these cases, the coordinates have been converted to SWEREF 99 TM with the help of two websites, either *rl.se (2023)* or *Lantmäteriet (2023b)*.

4. Results

4.1 Major Results

4.1.1 Identified Landfills Within Östra Mälarens Water Protection Area

32 objects have been identified as landfills within the Östra Mälaren water protection area. This is significantly more landfill objects than what was compiled in Ekman and Ejhed's (2022) where one landfill (Lövstatippen) was considered. The 32 identified landfill objects are presented in Figure 6. The landfills are distributed in the whole water protection area with a predominance in the densely populated areas along the eastern and southern part of the area. Only 1 of the 32 identified landfill objects has been verified as an active landfill, that is Pingstippen (see Appendix D) Depositing of excavation masses and snow during the winter season is believed to occur (Järfälla municipality, 2022). However, most identified landfills are believed to be inactive. In the EBH database or from the contacted municipalities, 25 landfills have been noted as inactive, which means that no information about the mode of operation (inactive or active) could be found about 6 landfill objects.

Figure 6. The 32 identified landfills within the Östra Mälaren water protection area. The map image has been created in QGIS by the author.

4.1.2 PFAS Results from the Field Samples Taken in Connection to the Landfills in Focus

Even though one of the selected landfills in focus are situated outside the water protection area of Östra Mälaren, the runoff from each landfill is however discharged within the water protection area Östra Mälaren due to technical or natural catchment area lineations which is seen in Figure 7. In the same figure, the geographical location of the study's field sampling locations in connection to the four landfill areas in focus are also seen. Although the sampling locations are not all within Mälaren-Görväln, it is considered that the flows in the end reach this basin (Ekman and Ejhed, 2022).

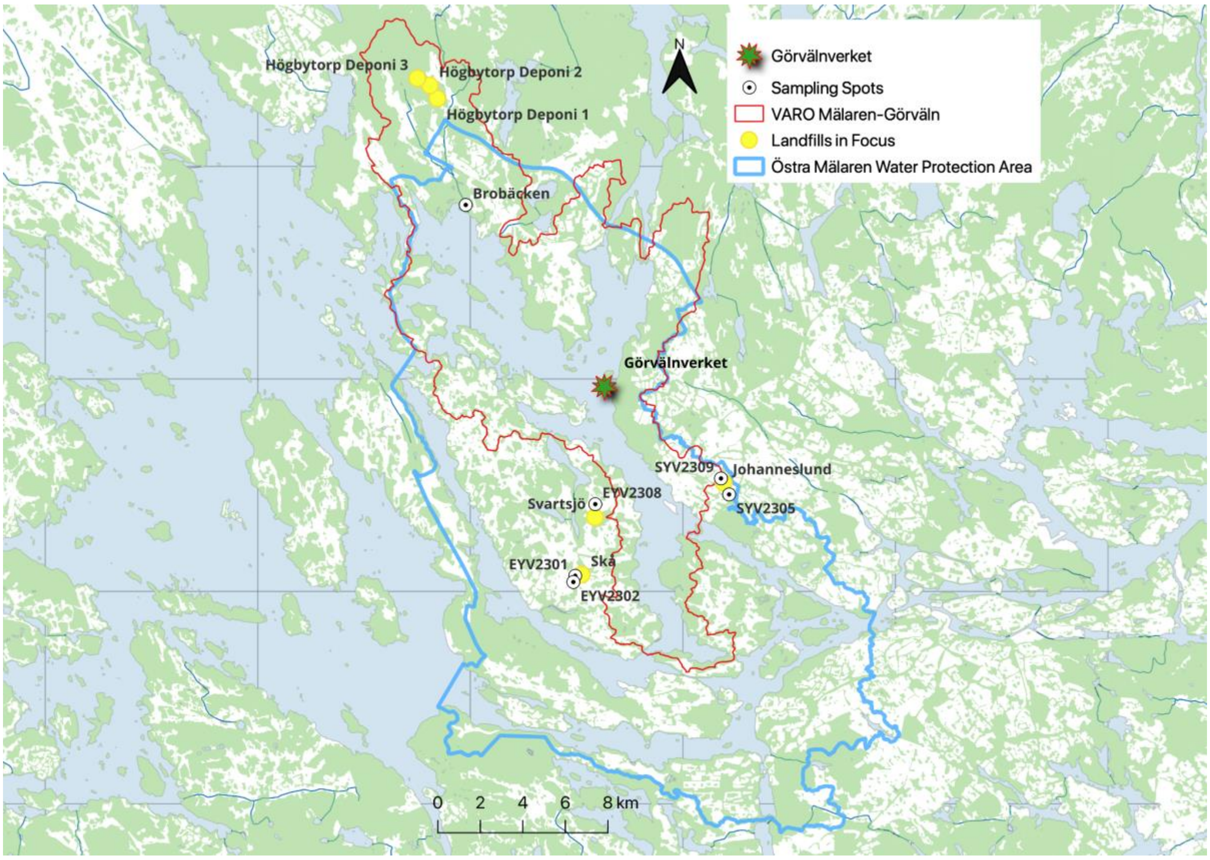

Figure 7. The four landfills (if the three landfills at Högbytorp are grouped as one) in focus and the locations where sampling has been performed within the scope of the study. The map also displays the borders of the Östra Mälarens water protection (blue) area and Mälaren-Görväln VARO (red). The map image has been created in QGIS by the author.

The results of the measured concentrations of PFOS, PFAS-4, PFAS-11 and PFAS-21 in this study's field sampling locations are presented in Figure 8. In Figure 8 it is visualised that the highest PFAS sum levels has been detected in Brobäcken (PFAS-4: 100 ng/l, PFAS-11: 310 ng/l and PFAS-21: 311ng/l). It can also be noted that for all samples the levels detected of PFAS-11 make up the majority (almost all) of the concentration of PFAS-21. At SYV2309 (downstream Johannelund) the results also show that PFAS-4 accounts for the majority of both PFAS-11 and PFAS-21.

Interestingly, higher sum concentrations of PFAS in EYV2301 (downstream Skå) have been measured compared to EYV2302 (further downstream Skå), despite EYV2302 being located more downstream Skå and was believed to collect a larger part of the landfills discharge in comparison to EYV2301. The lowest level has been detected in EYV2308 which was considered a downstream sample from Svartsjö. At EYV2308, PFOS was the only PFAS detected in the analysis.

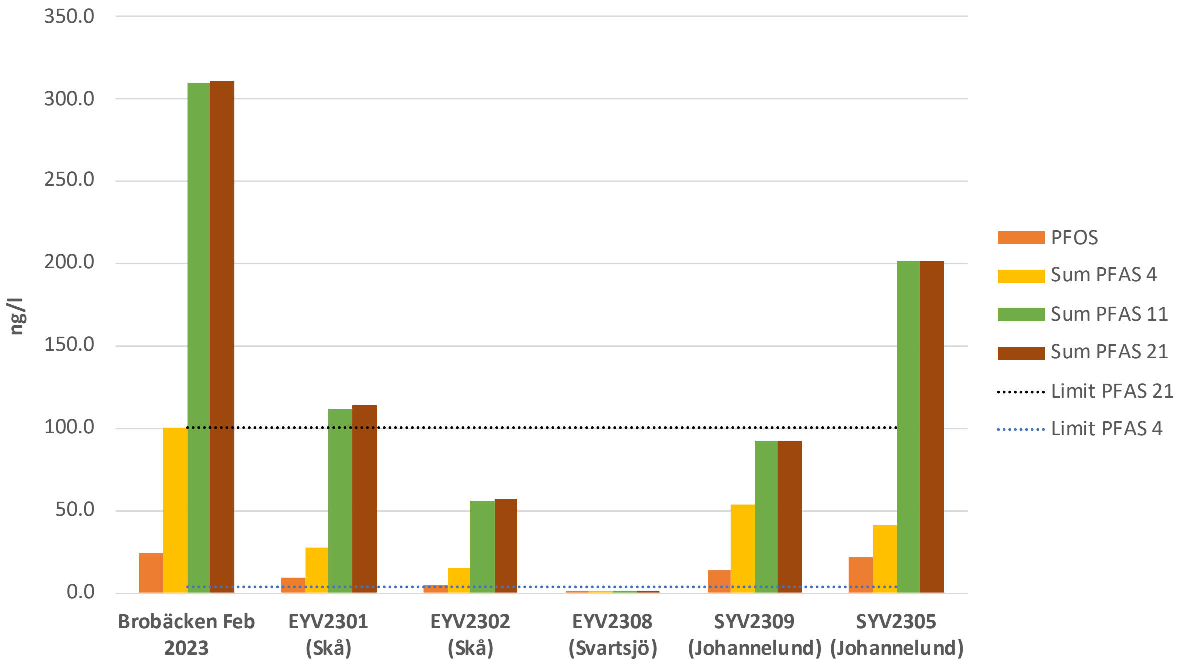

Figure 8. The detected concentrations of PFOS and the sum levels PFAS-4, PFAS-11 and PFAS-21 at the samples collected in the scope of the study. The sample in Brobäcken was collected in February and the rest in Mars (all in 2023). The sum of PFAS-4 and PFAS-21 are also compared to the Swedish Food Agency's guiding values (soon to be limiting values) for drinking water (LIVSF 2022:12).

In Table 8 the concentration levels at this study's field sampling locations are also compared to results of PFAS concentrations measured upstream and downstream of Högbytorp (RY202 and Y208 respectively) by Ragn-Sells at different times during 2022 and levels measured at Brobäcken at two different occasions in 2022 by Norrvatten (same sample location as in this study). All these PFAS sampling results are also compared to existing quality requirement values and soon to be limit values according to drinking water regulations (LIVSF 2022:12). If the measured concentrations of PFAS exceeds these comparative values they are marked with yellow colour in the table.
Table 8 indicates that the measured levels of PFAS at the sampling locations included, except EYV2308 and RY202, exceeds at least on soon to be limit values. Overall, the results from EYV2308 and RY202 (Mars-October) are low in comparison to the other samples. It can also be seen that the detected PFAS in SYV2305 (downstream Johannelund) and in Brobäcken exceeds all guiding and limiting values.

*Table 8. The levels PFOS as well as the sum of PFAS-4, PFAS-11 and PFAS-21 measured in this study's field sampling and levels previously measured by Ragn-Sells (RY202, Y208) and Norrvatten (Brobäcken in 2022). The levels are given in ng/L. The levels of PFOS and PFAS-11 are compared to the classification and environmental quality standards regarding surface water, that is 0.65 ng/L (yearly average) and 90 ng/l, respectively (HVMFS 2019:25). 90 ng/l of PFAS-11 is also a limiting value for raw water in a water resource used for drinking water (HVMFS 2019:25). For PFAS-4 and PFAS-21 the results are compared to the Swedish Food Agency's guideline values for drinking water (Livsmedelsverket, 2023). Where values are missing, no PFAS data were available*e*. Concentrations of PFAS exceeding the comparative values are marked with yellow colour in the table.*

Sample	Site	PFOS	PFAS 4	PFAS 11	PFAS 21
EYV2301 Mar 2023	Skå	9.2	27.2	112	114
EYV2302 Mar 2023	Skå	4.7	15	56.1	57.1
EYV2308 Mar 2023	Svartsjö	0.5	0.49	0.49	0.49
SYV2309 Mar 2023	Johannelund	13.2	53.9	92.6	92.6
SYV2305 Mar 2023	Johannelund	21.3	41.2	202	202
Brobäcken Feb 2023	Brobäcken	24.0	100	310	310.9

Brobäcken Nov 2022	Brobäcken	39	260	1100	
Brobäcken Aug 2022	Brobäcken	30	160	570	
RY202 Mar 2022	Högbytorp	0.35	2.21	8.5	
RY202 Sept 2022	Högbytorp	0.92	2.06	8	
RY202 Oct 2022	Högbytorp	0.69	2.02	10	
Y208 Mar 2022	Högbytorp	21	143.7	600	
Y208 Sep 2022	Högbytorp	190	1233.7	7300	
Y208 Oct 2022	Högbytorp	95	589	2800	
Comparative Values		0.65*	4**	90*	100**

**Guideline values for the environmental quality standard in inland surface waters according to HVMFS 2019-25.*

*** Guideline values until 2026, from then onwards limit values according to LIVSFS 2022:12*

In Figure 9, levels of PFAS-4 and PFAS-11 detected at Y208 and Brobäcken at three different sample occasions in 2022 are presented. Note here that the months for sampling differ between Y208 and Brobäcken.

The comparison between different levels measured at Y208 and in Brobäcken indicates that overall lower levels are detected at Brobäcken as expected due to dilution and possible retention by biota uptake in the watercourse between the sites. Higher levels are detected at Y208 during Högbytorps leachate irrigation period (April-September). Interestingly, lower levels are however detected at Brobäcken in August compared to in November. The detected levels at Brobäcken in February 2023 presented are the same levels seen in Figure 8, where they were the highest measured levels compared to the other sampling locations.

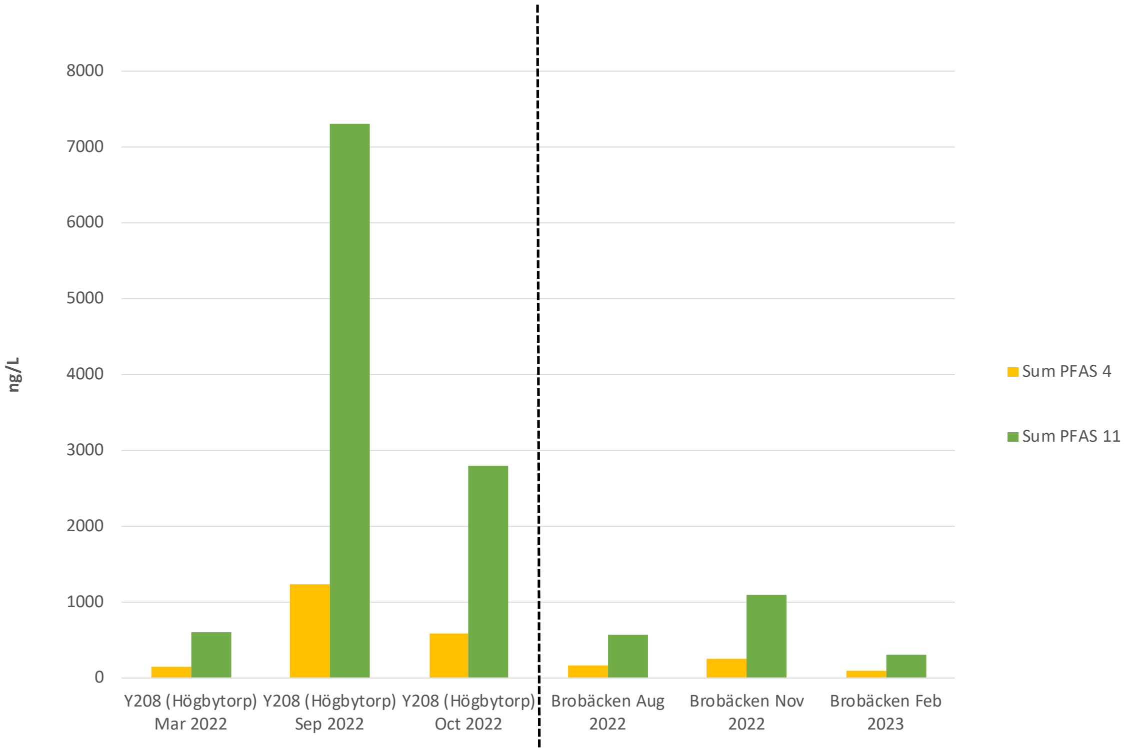

Figure 9. The concentrations of the sum of PFAS-4 and PFAS-11 measured by Ragn-Sells at Y208 (downstream Högbytorp) and by Norrvatten at Brobäcken.

In Figure 10 the relative distribution of the single PFAS detected in this study's field samples are presented. The PFAS displayed in the legend are the ones detected in the laboratory analysis. The PFAS encountered in the analysis for all samples, except for EYV2308 where only PFOS was detected, were *PFHxA, PFHpA, PFOA, PFBS and PFOS.*

Visually, it is indicated that PFAS composition in SYV2305 and SYV2309, both downstream of Johannelund, differ. Especially the detected levels of *6:2 FTS, PFBA, PFpeA* and *PFHxS* in SYV2305, which were not detected in SYV2309. The comparison of PFAS composition in the samples downstream Skå, EYV2301 and EYV2302, shows more similarity. Of the PFAS types analysed the same were detected in EYV2301 and EYV2302.

6:2 FTS were only found in Brobäcken and at SYV2305. It can also be noted that higher levels of PFSA (sulfonic acids) were detected at Brobäcken in comparison to the other sampling locations.

It was only by Johannelund (SYV2305 and SYV2309) that PFDA was detected. At these sampling locations PFNA was also detected which was only otherwise found in Brobäcken.

The levels and composition (only PFOS) of PFAS detected at sampling location by Svartsjö (EY2308) cannot visually be seen as the levels are much smaller in comparison to the rest of the sampling results.

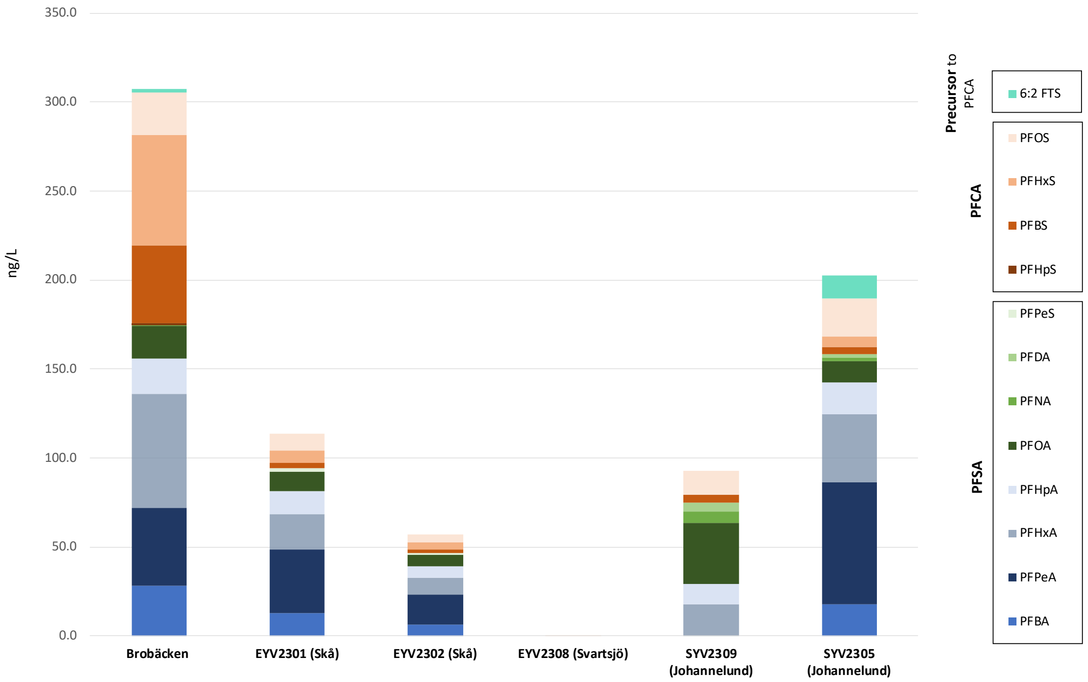

Figure 10. The relative distribution of different PFAS detected at the study's sampling locations. In the legend menu the different PFAS are grouped as either PFCA or PFSA substances or as a precursor to one of these two groups.

4.1.3 Estimated Load of PFAS

4.1.3.1 Estimations of PFAS load at the Sampling Locations and at Y208 (Method 1)

The calculated mass levels of PFAS per year, based on the concentrations detected at the sampling locations and the measured water flows are presented in Table 9. Additionally, Table 9 includes the calculated average year mass at Y208 (same method as Ragn-Sells has used) and an estimated mass flow based exclusively on the sample taken Mars 2022 at Y208 and the measured flow for that day. As expected the different calculations method used for estimating the yearly load at Y208, gives different results. The average year quantity method results in higher values for PFOS, PFAS-4 and PFAS-11 compared with the load based exclusively on the sample taken in Mars 2022.

Table 9. Calculated mass of PFAS at the sampling locations and at Y208 with the help of measured water flow at the sites. The mass of PFAS at the sample locations by Johannelund is not included, as the water flow was not measured at the time of sampling.

	Flow	**PFOS**		**PFAS 4**		**PFAS 11**		**PFAS 21**	
	m^3/s	ng/l	g/year	ng/l	g/year	ng/l	g/year	ng/l	g/year
EYV2301	0.03	9.2	9.1	27.2	26.8	112.0	110.2	114.0	112.2
EYV2302	0.02	4.7	3.6	15.0	11.7	56.1	43.8	57.1	44.6
EY2308	0.11	0.5	1.8	0.5	1.8	0.5	1.8	0.5	1.8
Brobäcken 8 Feb 2023	0.12	24.0	89.0	100.0	370.9	310.0	1149.9	310.9	1153.4
Y208 - 24 Mar 2022	0.04	21	26.6	143.7	182.1	600	760.4		
Y208- Average year quantity (2019-2022)			44		215		980		

In Figure 11 the results can be seen visually in a graph. Brobäcken shows the largest load of PFAS depending on the measured water flow at the sampling location, which is three times as large as the flow at Y208 (24 Mars 2022). The measured water flow at Brobäcken is also higher than the previously measured flows at the same location in August and November 2022 (0.013 m^3/s and 0.012 m^3/s, respectively).

As the measured water flow at EYV2301 was slightly higher than for EYV2302 (as well as the concentrations), the estimated load at EYV2301 was also higher.

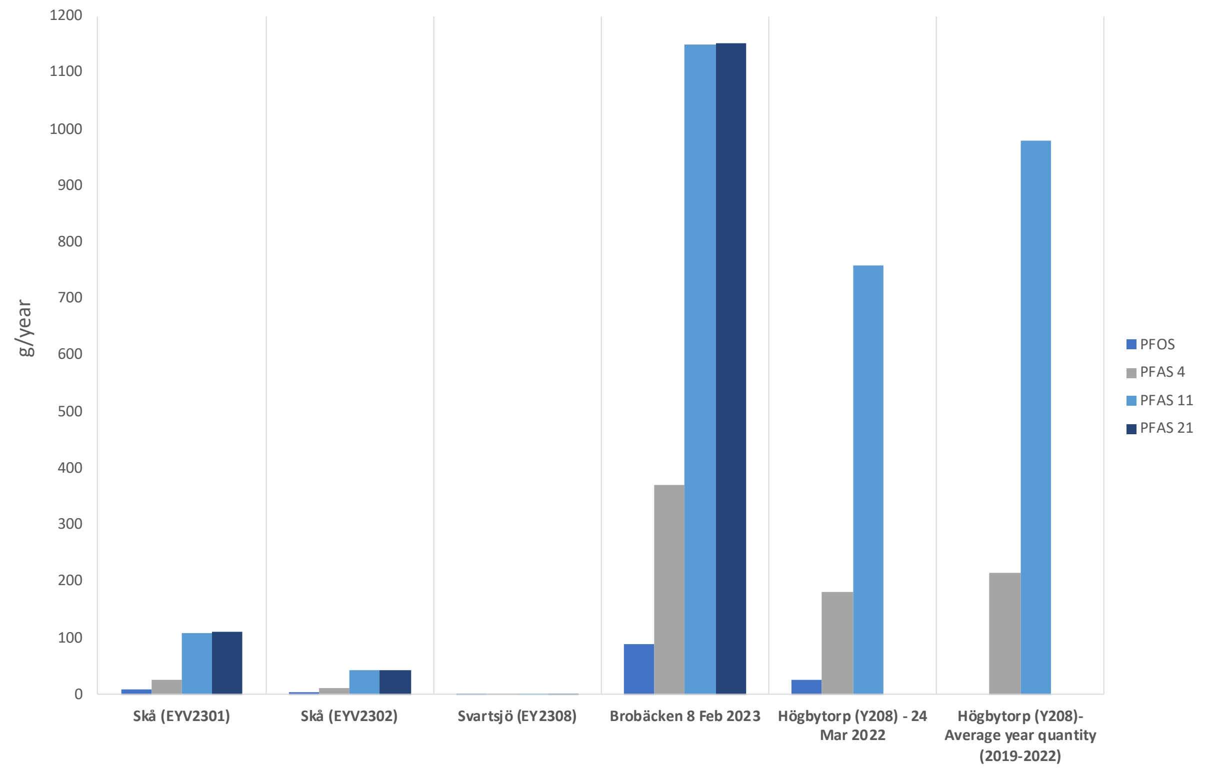

Figure 11. Calculated mass flow of PFOS, PFAS 4, PFAS 11 and PFAS 21 per year at the different sampling locations and at Y208 using two different approaches.

4.1.3.2 Estimation of PFAS Load Using the Calculated Leachate Discharge from Skå, Svartsjö and Johannelund landfill (Method 2)

The calculated leachate generated at the landfills per year are presented in Table 10 together with the used input parameters. The two different leachate discharges calculated towards SV2305 (Råcksta träsk) and SYV2309 (Mälaren-Görväln) are both included. The calculated leachate is primarily dependent on the area of the landfill. Which explains why Svartsjö has the smallest estimated leachate discharge, while Johannelund has the largest.

Table 10. The estimated leachate outflow per year from the landfills using the simplified water balance

	Skå	Svartsjö	Johannelund (Råcksta träsk)	Johannelund- (Mälaren-Görväln)
Precipitation catchment area (mm/year)	694	690	695	694
Evapotranspiration catchment area (mm/year)	469	483	453	470

Area landfill (m2)	14817	6502	50000	25000
Out flow of leachate (m3/year)	**3334**	**1346**	**12100**	**5600**

The estimated loads (g/year) with the calculated yearly leachate discharge from the landfills are visualised in Figure 12. The highest amounts of PFAS are estimated to come out from Johannelund with the leachate (PFOS: 0.3 g/l, PFAS-4: 0.8 g/year, PFAS-11: 3.0 g/year, PFAS-21: 3.0 g/year) and the lowest amount (only PFOS) from Svartsjö. It was decided to use the levels measured at EYV2301 to estimate the load from Skå landfill, as the sample's measured PFAS levels were higher than the ones at EYV2302 (more downstream Skå) and thus, is believed to be a better indicator for the real PFAS load. Furthermore, when estimating the load from Johannelund the PFAS levels measured at SYV2305 and SYV2309 were both included as both samples are within catchment areas whose flows finally reach Mälaren-Görväln. The estimated loads of PFAS visualised in Figure 12 are minor in comparison to the estimated loads using Method 1(seen in Figure 11) as the calculated leachate, based on the landfill areas and SMHI S-HYPE data, was much smaller compared to the water flows measured by the sampling location during the field work. The result of method 2 (seen in Figure 12) was included as an attempt to estimate the loads that specifically may be a source from the landfills alone.

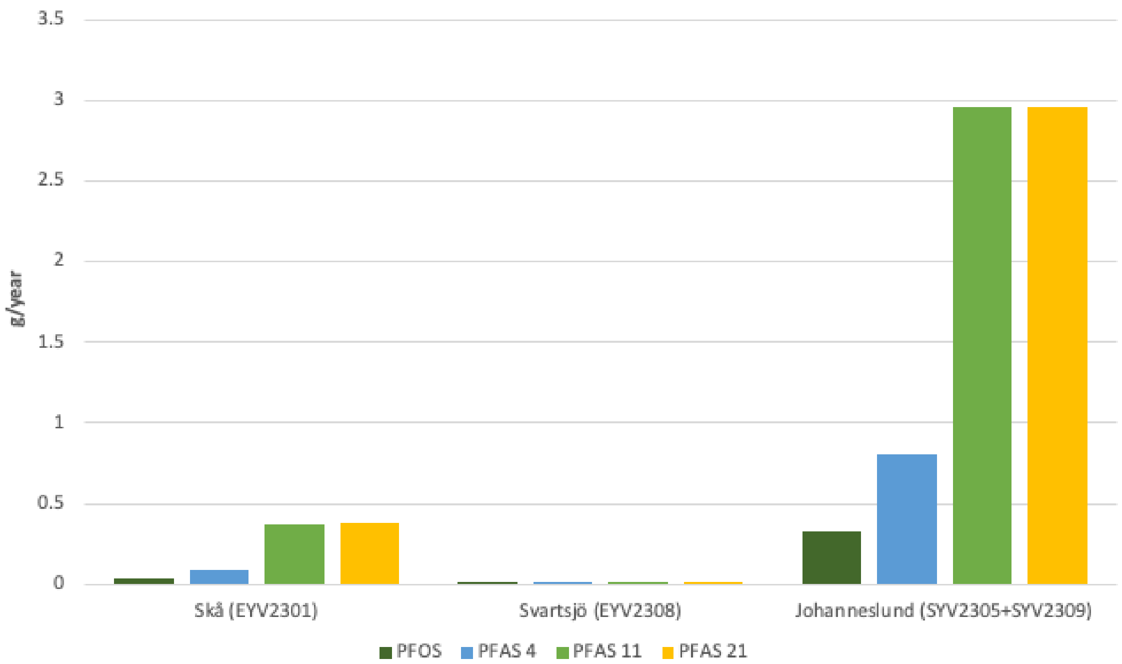

Figure 12. The estimated PFAS mass in leachate [g/year] coming§ from Skå, Svartsjö and Johannelund landfill.

4.1.4 PCA

The results of the two performed PCA tests, PCA **A** and PCA **B**, are seen in Figure 13 and Figure 14, respectively.

PCA **A** (Figure 13) is submitted to the water chemistry data measured at the sampling spots (including data accessed from Högbytorp), as well as in the raw water at Görvälnverket, and in a leachate type example.

As the first principal component (PC1) explains most of the variance between the samples, it appears from the component plot (loading plot) that the water chemistry between downstream Högbytorp (Y208) and upstream Högbytorp (RY202) together with downstream sample at Svartsjö (EYV2308) differentiates the most (they are negatively correlated). The raw water at Görvälnverket, upstream Högbytorp (RY202) and downstream Svartsjö (EYV2308) are grouped together which implies that the water chemistry samples are similar to each other. The water chemistry at EYV2302 and EYV2301 (both downstream Skå) seems to vary, despite the fact that the sample locations are located relatively close to each other (around 300 metre (VISS (2023)). The water chemistry for the leachate type example and SYV2305 (downstream Johannelund and close to a larger road), appear to resemble each other.

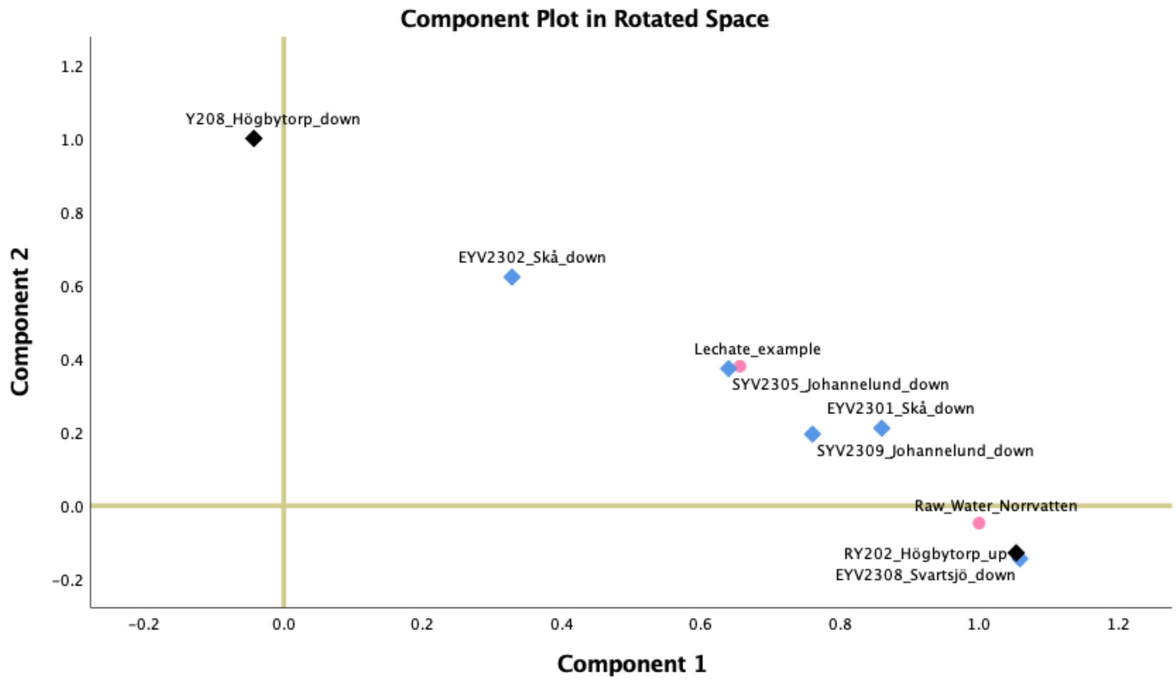

*Figure 13. The result of PCA **A** visualised in a loading plot. The blue diamonds represent the samples taken in the field in this study. The black diamonds represent the Högbytorps samples downstream (Y208) and upstream (RY202) the facility. The pink dots represent the water chemistry data found in literature, that is the leachate type example and the raw water at Görvälnverket. Component 1 and 2, together explained 89.3 % of the variance (79.5% and 9.8% respectively).*

PCA **B** (Figure 14) is presented through a biplot (score plot and a loading plot) and is subjected to the different PFAS levels detected at the sample locations, also incorporating the PFAS data upstream and downstream of Högbytorp. Furthermore, sampling of PFAS levels in the raw water by Görvälnverket, in precipitation, in sewage water and in leachate are included for comparison. The biplot describes the similarity or dissimilarity between the different samples and also gives information of the relationship between the variables (the individual PFAS).

PC1 explaining most of the variance (54.9%), indicates that the PFAS levels measured in the leachate and in Y208 (downstream Högbytorp) differ the most from the levels detected in EYV2308 (Svartsjö), RY202 (upstream Högbytorp), precipitation and in the raw water extracted by Norrvatten. These four last mentioned samples are closely grouped together, suggesting that they are similar to each other. The sewage water sample and the samples taken in connection to Skå landfill (EYV2301, EYV2302) also seem to show similarity, however, EYV2301 deviates slightly.
It is also indicated that the samples by Johannelund (SYV2309, SYV2305) and in Brobäcken do not differ that much in relation to PC1, however, they vary considering PC2 and the different individual PFAS levels detected in the samples.

PC2 (explaining 24.6 % of the variance) also indicate that despite that the leachate sample and Y208 (downstream Högbytorp) differ from the rest of the samples, they also show great variation. As indicated from the individual PFAS loadings projection (green lines) Y208 and the leachate sample differ considering the individual PFAS levels. Higher levels of PFOA, PFOS and PFBA are related to the leachate sample in comparison to Y208 for example, which is more affected by PFBS and PFHxS. Furthermore, it seems as Brobäcken and Y208 are affected by the same individual PFAS, however at different levels.

The sample points on the right-hand side of the diagram are in general the observation with the highest PFAS levels measured.

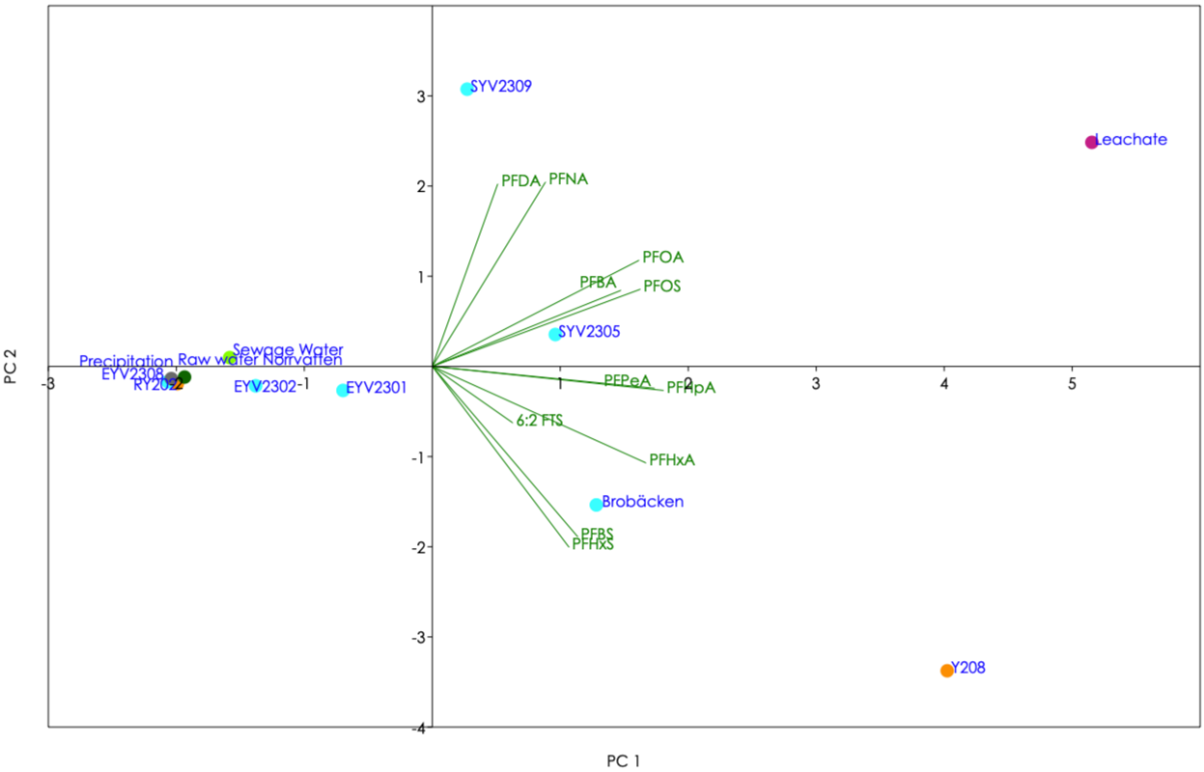

*Figure 14. The result of PCA **B** visualised in a biplot. The subject data is the concentrations of PFAS measured at the field sampling locations and at Högbytorp (Y208 and RY202). PFAS concentrations from other cases (extremes) are also included such as, from the raw water at Görvälnverket, precipitation, sewage water and leachate. PC 1 and 2, together explained 79.5 % of the variance (54.9 % and 24.6% respectively).*

5. Discussion

5.1 Landfills as Potential Sources of PFAS Released to Östra Mälaren

32 landfills have been identified within Östra Mälaren, which is more than what was included in the previous compilation by Ekman and Ejhed (2022), where only one landfill (Lövstatippen) was considered. Högbytorp was also included in Ekman and Ejhed (2022) analysis, but as previously mentioned is not located within the Östra Mälaren water protection area. This indicates that at least 31 landfills can be sources of PFAS pollution to Mälaren-Görväln and Norrvatten's drinking water intake which has not been considered before. The sampling results connected to the focused landfills in this study indicates that PFAS is released from these four landfills, however at various levels.

Whether or not all the landfills identified within the Östra Mälaren water protection area constitute a risk of PFAS load to Mälaren-Görväln cannot yet be determined, as no PFAS sampling has been performed in the proximity of many of the landfills. All the identified landfills are registered in the EBH database, however, to the author's knowledge, most of these landfills have not previously been examined for PFAS leakage. This means that the risk classification presented in the EBH database of these landfills has been established without considering this contamination parameter. Consequently, it also implies that these objects are not prioritised by the municipalities for work regarding measures of PFAS contamination. More knowledge of the PFAS situations by the identified landfills are thus important to gather in order to be able to dismiss certain objects and to put more resources (i.e., time and money) spent on those that are hot-spots and a burden to Mälaren and other water bodies.

Furthermore, it cannot be ruled out that there may exist more landfills within the examined water protection area which are not registered in the accessed EBH-database. For example, potential contaminated areas owned by the Swedish Defence Forces have not been investigated as the data is not publicly available or that all old landfills simply have not been identified or communicated.

5.1.1 The Landfills in Focus

The PFAS sampling at the landfills in focus and the results from Y208, all show the occurrence of PFAS which exceeds some guiding or limiting values except for in the EYV2308 (Svartsjö) case. The PFAS levels and the composition of different PFAS types detected, however, varies between landfills sites and sometimes also between the samples that are collected next to the same landfill (see Figure 10). This is not surprising, as the landfill sites are conditioned by various different factors, such as hydrological conditions, landfill content, landfill area size and others. However, one difficulty when it comes to investigating specifically the landfills release of PFAS, is that in most cases a lot of activities are going on in close vicinity to the landfills which also can cause PFAS pollution to the surrounding environment. Examples of such include industries (Johannelund) or temporary storage of different types of waste (Skå and Högbytorp). This means that the sampled water is a mixture of precipitation, leachate and water from other operations which may transport PFAS contamination. Therefore, the results of the estimate of PFAS being released from the landfills with the leachate should be interpreted with great care. Below the sources of the detected PFAS levels at the sample locations and at Y208 (downstream Högbytorp) are discussed more in depth.

5.1.1 Skå Landfill as a Potential Source of PFAS

The concentrations of PFAS measured at the samples next to Skå landfill shows that higher levels of PFAS were detected at EYV2301 (PFAS-21:114 ng/L) compared to EYV2302 (PFAS-21: 57 ng/L) which is located more downstream than EYV2301.
As indicated by Figure 10 the same PFAS specific substances were detected at both sample locations, which can indicate that the same PFAS source or sources are reaching both sample locations but that the further downstream sample location is more diluted. Skå landfill is located close to a ÅVC which is partially located within the same catchment area as the landfill. This means that the ÅVC can also be a source for the measured PFAS concentrations. Furthermore, the site has previously been used as a firefighting testing ground and today sewage sludge is stored west of the landfill (within the same catchment area as the landfill), which also can constitute sources of PFAS.

As shown in PCA **B** the levels of the different PFAS detected in both EYV2301 and EYV2302 seems relatively correlated with the levels found in a sewage water example. This result could be plausible considering that sewage sludge is stored at the landfill as well as the fact that it is believed the landfill contains household waste mixed with sewage sludge and latrine.

The higher levels detected in EYV2301 compared to EYV2302 can be an incidental result dependent on external factors that cannot be predicted, i.e. a temporary release of contaminated water at the location or unknown hydrogeological conditions such as the groundwater flow spreading in several directions, which can affect the dilution. Interestingly, PCA **A** indicates that the water chemistry differs between the two sample spots which could imply that the sample locations are affected by different water flows (i.e., maybe one of the sample locations is penetrated by groundwater to a larger degree than the other). However, more repeated sampling of PFAS and a more extensive investigation of the hydrological conditions in the area are needed to make any reliable conclusions around this.

5.1.2 Svartsjö Landfill as a Potential Source of PFAS

The sampling result from downstream of Svartsjö landfill (EYV2308) showed the lowest concentrations of PFAS in comparison to the other measured samples which was not surprising. Svartsjö is the only landfill (of the four in focus for the current thesis) that has no industrial area located in its vicinity and its estimated area is believed to be the smallest. Only PFOS was detected in the measured sample which may also confirm that the waste present at the landfill is relatively old.
It is indicated in PCA **A** that the water chemistry at EYV2308 resembles the water chemistry in upstream Högbytorp (RY202) and in the raw water at Norrvatten rather than the rest of the included sample, which could indicate that Svartsjö landfill is in such a state that relatively small amounts of leachate is released from it.

5.1.3. Johannelund Landfill as a Potential Source of PFAS

The Johannelund landfill is located within an urban area where a network of stormwater pipes exists to divert the rainwater, thus the choice of sample locations was restricted to the stormwater wells. First of all, the sample SYV2305, which detected higher levels of PFAS (PFAS-11:202 ng/l) compared to SYV2309 (PFAS-11: 93 ng/l), were located next to a large road (Lövstavägen) around 610 metres (VISS, 2023) from the landfill centre (see Figure 4).

This means that discharge originating from other places than the landfill runs through SYV2305. The point receives, among other sources, a share of the stormwater originating from the western parts of Vinsta industrial area, which could explain the high levels of PFAS detected at the sample point. SYV2309 is, on the other hand, located north-west of the landfill, around 225 metres (VISS, 2023) from the landfill centre. It may indicate that the PFAS detected at this point is more representative of the PFAS released from the landfill. Here, no levels of PFBA, PFPeA, PFHxS (short chain PFAS) or 6:2 FTS (long chain) were detected, which all were detected at SYV2305.

Another interesting observation is that of all the sampling in the field and when compared to measurements at Y208, PFDA was only detected at SYV2305 and SYV2309. This may indicate that there exists a specific source (potentially not that common) in the landfill or in the surrounding area that releases PFDA or that the source releases relatively large amounts of PFDA. According to the Swedish Food Agency (2015), PFDA is included in both the "old generation" and the "new generation" of highly fluorinated fire extinguishing foams, which could mean that the present PFDA originates from diffuse sources of the use of fire foam. This hypothesis is also supported by the fact that data compiled by Rosenqvist (2020) at the request of the Swedish Environmental Protection Agency, which concerns locations where fire foam has been handled, present several sites in Vinsta industry area and one close to the EYV2309 where fire extinguishing foam has been used.

As the landfill area comprises three different catchment areas, discharge towards Mälaren-Ulvsundasjön has not been sampled. This certainly increases the uncertainty around the estimated PFAS load from Johannelund.

5.1.5 Högbytorp Landfills as Potential Sources of PFAS

Högbytorp facility as a whole releases PFAS to the surrounding environment which has earlier been established by Ragn-Sells (2022) when comparison of PFAS-11 levels between the upstream point (RY202) and the downstream point (Y208) was conducted. As indicated in this study's PCA **A**, the water chemistry in RY202 and Y208 appears to be very different which could potentially be explained by the notion that Y208 is more affected by contaminated water from the facility.

From the measured PFAS-11 levels at Y208 during 2022, it can however be seen that the concentrations vary depending on the month of sampling which can be explained by the irrigation season (April-September) of the treated leachate at the soil-plant system. In March (2022) the measured level was 600 ng/l, in September 7300 ng/l and in October 2800 ng/l. The levels detected in the end of the irrigation season (September) exceed both the median and average levels of PFAS-11 presented in the compilation study concerning PFAS in leachate by Miljösamverkan Sverige (2022) where the median and average value of PFAS-11 detected in leachate were 5476 ng/l and 1490 ng/L respectively, out of the 117 Swedish landfills included in the study. Comparisons between concentrations of PFAS should, however, be done with caution as concentrations are affected by the water levels at the time of sampling.

Furthermore, what has not been investigated sufficiently in this study is if the share of the PFAS received at Y208 originates from the leachate released from the landfills at Högbytorp. As Högbytorp is a large facility which receives many types of waste in large quantities which are managed in several different ways, the downstream sample location Y208 may receive contaminated water from other areas and processes taking place at the facility, not only from the landfills. However, 82 505 m^3 treated leachate from landfill 1 and landfill 3 (landfill 2 has a closed leachate system) was irrigated on the soil-plant bed system in 2022 (Ragn-Sells, 2022), which may indicate that other potential sources contribution of PFAS to Y208 is negligible. This is a suggestion for further investigation to conduct a more reliable evaluation. Due to the different situation of the handling of leachate at Högbytorp in comparison to the other landfills in this study and as around 62% of the landfill areas at Högbytorp are covered according to advice given by Naturvårdsverket (2004), led to the decision that the potential PFAS load, specifically from the landfills at Högbytorp, should not be estimated deploying method 2 in this study.

5.2 Load of PFAS from Landfills Contributing to the Mass Balance of PFAS in Mälaren-Görväln

The loads of PFAS-11 (g/year) from Skå, Svartsjö and Johannelund estimated with method 2 (using the calculated leachate discharge from the landfills), was evaluated to 0.37, 0.00066 and 3.0 respectively (the results for PFAS-21 are basically the same). In Ekman and Ejhed (2022), it is estimated that the total mass flow of PFAS-9 into Mälaren-Görväln basin is 31 000 g/year. If assumed that these estimated loads of PFAS from the landfills all end up in the Mälaren-Görväln basin (i.e., no retention in biota on the way towards the basin) and that PFAS-11 are comparable with PFAS-9 loads, these landfills share of the total inflow constitute 0.0012%, 0.000002% and 0.01%, which can be considered relatively minor values.

However, if considering the estimated PFAS-11 loads estimated with method 1 (using the measured water flow at the sample occasion) the share of the total inflow to Mälaren-Görväln coming from the grounds of Skå (EYV2301) and Svartsjö (EYV2308), constitute 0.36% (110.2 g/year) and 0.0058% (1.8 g/year). Which are more significant numbers, especially the share from Skå, if compared to the other load sources accounted for in Ekman and Ejhed (2022), such as precipitation which estimated PFAS-10 load was 55 g/year.

Furthermore, according to Ekman and Ejhed (2022) it is estimated that around 2800 g/year of PFOS originates from unknown sources within Mälaren-Görväln. The total estimated PFOS load from Skå, Svartsjö and Johannelund is 0.36 g/year (values based on method 2) which can be considered an insignificant share of the hidden statistics of PFOS sources. However, when looking at the mass flow results estimated for the sample locations by Skå (EYV2301) and Svartsjö (EYV2308) (values based on method 1) the PFOS load per year from these two locations are estimated to be 10.9 g/year which is a slightly more significant value. If the load of PFOS by the sample locations in connection to Johannelund (SYV2305 and SYV2309) could have been determined with a measured water flow at the time of sampling this value would most likely have increased further.

5.5 Reliability Discussion

The estimated PFAS loads calculated with method 2 are arguable considering the many calculation simplifications and assumptions made concerning the leachate discharge, but were included to try to estimate the loads originating specifically from the landfills and to give a mass flow estimate for Johannelund where the water flow at the sample location was not measured. The loads estimated using method 1 are probably more reliable as they are based on real water flows at the sample location. However, these loads embrace the potential loads from the activities also going on around the landfills and are thus assumably exaggerated as an estimate for the landfills load to Mälaren-Görväln.

Furthermore, the PFAS load determined by the sample locations (method 1) should also be considered with caution as the yearly load is based on one single sampling and measurement occasion during the year. Naturally, the water flow varies over the year (SMHI, 2023b) and thus repeated PFAS sampling and measurements of water flows at the locations are needed to get a more reliable result of the yearly load of PFAS. For example, the results from Malnes et al. (2021) indicated that the concentration sum of PFAS-13 was in general higher during the autumn compared to the spring in surface waters in Mälaren.

More continuous sampling of PFAS levels over the year is also desirable at the sampling point downstream Högbytorp (Y208) to be able to make more reliable estimates of the yearly load of PFAS released from the facility as a whole, especially as irrigation of treated leachate occurs at specific periods during the year which creates large fluctuations of PFAS concentrations. Previously, Ragn-Sells (2022) has presented the yearly load of PFAS-9 in Y208 to be 900 g/year. When using the same calculation method and the same data as Ragn-Sells for calculating the estimated yearly load of PFAS in Y208, this study estimates that the yearly load of PFOS and PFAS-11 received at Y208, is 44 g/year and 980 g/year, respectively. It should be noted that this estimated PFOS load is smaller than the value used by Ekman and Ejhed (2022), which was estimated to be 66 g/year.

Furthermore, continuous sampling of PFAS and water flow measurement in Brobäcken is also desirable. As the yearly load of PFAS-11 in Brobäcken estimated in this study using method 1 is based on a single sample collected in February which is a time of high flow rate, this result should be interpreted with care. Further, it might not be appropriate to compare it with the yearly load estimated at Y208 with the method used by Ragn-Sells, as the latter is based on more PFAS samples and water flow data. Ideally the more samples of PFAS and water flows should be collected simultaneously at Brobäcken and Y208, to obtain more reliable results which could support the understanding of the share of PFAS load originating from Högbytorp which reaches the outlet of Brobäcken towards Mälaren-Görväln per year.

Additionally, the retention of PFAS and other substances in biota varies depending on the season which affects the transport of PFAS. In February, for example, it is likely that less PFAS is retained in biota as it is outside the growing season. In addition to dilution and absorption in biota, the transport of PFAS contaminants can also be affected by retention through adsorption to organic carbon in the soil and in watercourses. The Kd value may also vary significantly for individual PFAS as described and discussed more in depth in Rovero et al. (2021). Thus, the relative levels of PFAS detected at the sample locations will be changed as the PFAS contaminants reach Mälaren-Görväln.

5.6 Validity Discussion

In the current study, sampling of PFAS has only included surface water samples. This means that other pathways of PFAS leakage from landfills have not been considered, pathways such as transport through the groundwater or accumulation in soil and the potential contribution from precipitation. This means that the PFAS contamination at the investigated locations is more complex and probably more comprehensive than assumed in this study. It has, for example, previously been suggested by the completion study of PFAS in landfill leachate performed by Miljösamverkan Sverige (2022), that higher levels of PFAS were detected in the groundwater compared to surface water samples. Which, however, is expected as the groundwater water flows are smaller leading to higher concentrations. It should also be remembered that only a small share (24 PFAS has been targeted) of all the existing PFAS circulating in the society has been considered in the current study. The knowledge about PFAS at the sampling locations in focus for this study is therefore still limited.

As indicated by SGI (2011) estimations of leachate discharge from landfills can often only be approximated as it is difficult to determine the included parameters. This is also the case in the current study where a simple water balance was used, including the precipitation, evapotranspiration and the estimated landfill area. Other parameters, such as the deposited waste's hydraulic capacity, landfill decomposition state or potential groundwater intrusion were not considered in the leachate calculations as there was limited data available about the landfills' composition and content. The yearly precipitation and evapotranspiration within the specified partial catchment area used for the water balance was accessed from SMHI's S-HYPE model. According to SMHI (2023a) the data generated in S-HYPE should be seen as indicative rather than completely trustworthy. This is the case as the model performs statistical calculation from a large dataset of points which cannot always generate correct reporting for small individual locations. However, the generated data was used as making measurements of precipitation and evapotranspiration at the landfills was not within the scope of this study.

Furthermore, due to the approximate leachate discharge from the landfills and as PFAS levels detected were assumed to originate from the leachate only, the estimated load of PFAS transported from the landfills (method 2) should only be interpreted as indications.

In order to try to provide a better understanding of the sources of the detected PFAS which would be needed to assist future investigations and measurements, this study performed two PCAs of the collected data. However, due to the small size of the datasets included in both PCA **A** and PCA **B**, the normal distribution is not mirrored in the presented PCAs, which also was indicated by the PCA criteria which was not properly fulfilled (i.e., the measure of sample adequacy for PCA **B** was too small). Thus, the results of the PCAs should be interpreted with caution and not be seen as completely truthful, rather they should be interpreted as potential trends. To improve the source tracing of PFAS and to apply PCA in a more meaningful way, more observations (samples) should be included and also be compared with a larger collection of potential primal sources, such as samples previously collected at fire testing grounds and more variating cases of leachate samples.

5.7 Future Measures Against PFAS Pollution - A Brief Outlook

As indicated before and also established in this study, landfills are sources of PFAS pollution to the environment. What is important to question, however, is where the PFAS problem actually lies and where measures to avoid further PFAS pollution make the most difference. Landfills constitute a service of societal importance where unwanted products containing PFAS are collected. This implies that landfills will continue to be a route for PFAS pollution as long as PFAS is used in products produced in society. Simply making demands that leakage of PFAS from active landfills should stop will not, on the whole, reduce new PFAS spreading and its negative environmental and health effects. Thus, the spread of PFAS also needs to be managed upstream landfills and other PFAS pathway nodes, starting at the use of PFAS in produced products. At the moment, a proposal to ban all non-essential PFAS within the EU is discussed (ECHA, 2023). Hopefully, these requirements will be passed so that the spread of PFAS in the society stops increasing and so that the costs and resources to prevent PFAS leakage from landfills over time also can be reduced.

6. Conclusion

6.1 Conclusions

This study has investigated landfills as a potential source of PFAS load to Mälaren-Görväln and its raw water used to produce drinking water at Görvälnverket owned by Norrvatten. It has been highlighted that at least 32 landfills are located within the water protection area of Östra Mälaren surrounding Görvälnverket and the vast majority of them has not yet been risk assessed in relation to possible PFAS contamination. In this study, three of these thirty-two landfills have been investigated for possible PFAS leakage to Mälaren-Görväln. Also, Högbytorp facility which incorporates 3 landfills has been included in the investigation. At all sample locations with connection to a landfill, PFAS has been detected. However, the levels are varying depending on the size of the landfill and on the human activities going on in close vicinity to the landfills. The estimated loads of PFAS at the sample locations in the vicinity of the studied landfills are considerable regarding other PFAS sources that are believed to have an impact on Mälaren-Görväln. However, the challenge has been to determine the landfills' share of these loads. Furthermore, the estimates represent uncertainty, especially since a limited set of data was collected and used in the analysis. The latter also made it difficult to trace the sources of the detected PFAS. To draw more reliable conclusions of landfills' impact on Mälaren-Görväln, a more in-depth risk assessment is required, with more sampling, preferably also examining PFAS pollution to groundwater and soil.

6.2 Limitations

No statistical uncertainty analysis has been possible to conduct in this project due to the deficient data available.

6.3 Future Work

This study has specifically focused on identifying landfills existing within the Östra Mälaren water protection area. However, future work could include landfills located within the whole catchment area which ultimately contribute with water flows towards Mälaren-Görväln water body in order to get a more comprehensive understanding of potential landfills which could constitute key sources of PFAS.

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8. Appendix

A Assumptions

Table 10. The Assumption made throughout the performance of the PCAs.

No	Assumptions for the Produced PCAs
1	Values of total hardness (mg/L) of water can be converted to German degrees of hardness (dh°) with the help of the following relation 1 dh° = 7.1 mg/L (MIVA, 2022). It was also assumed, for the sake of simplicity, that calcium responds to 100% of the hardness. This assumption was used to determine the water hardness of the leachate type example and of the raw water at Norrvatten.
2	Conversion from $N - NH_4$ to NH_4^+ follows the following relation $1\ mg\ N - NH_4 = 1.3\ mg\ NH_4^+$ (Bydén et al., 2003)
3	Conversion from $NO_3 - N$ to NO_3^- follows the following relation $1\ mg\ NO_3 - N = 4.4\ mg\ NO_3^-$ (Bydén et al., 2003)
4	Conversion from $PO_4 - P$ to PO_4^{-3} follows the following relation $1\ mg\ PO_4 - P = 3.1\ mg\ PO_4^{-3}$ (Bydén et al., 2003)
5	Conversion from $NO_2 - N$ to NO_2^- follows the following relation $1\ mg\ NO_2 - N = 3.3\ mg\ NO_2^-$ (Bydén et al., 2003)
6	It is assumed that the leachate water example used for comparison in PCA **A** is representative of a leachate water even though the values for water hardness and NO_3collected from a separate source.
7	For reported concentrations expressed as under the reporting limit (LOR) in the result from the laboratory analysis, PCA A has used reported values reported after the less than sign (<) in order to have sufficient amounts of values over 0 for the statistical analysis. This was however not done in PCA B where all PFAS concentrations reported lower than LOR were set to zero.

B Field Equipment used

Below a list of the field equipment used are presented.

- HQ series Multi (Hach)
- Field sampling bottles (named with location, date, organisation and sample type)
- Plastic gloves
- Dry napkins - to dry the HQ series Multi after rinsing with deionised water
- Deionised water
- Field cooling box
- Cooling blocks - taken from the freezer att Görväln before taking off to the field
- A Thumb stick
- Measuring tape
- 2 oranges
- A peristaltic pump (12 VDC Eijkelkamp) and plastic tubes

C Principal Component Analysis Data

*Table 11. The data used to generate PCA **A**.*

		EYV2301	EYV2302	EYV2308	SYV2309	SYV2305	Högbytorp RY202	Högbytorp Y208	Leachate water example	Raw Water Norrvatten
		2023/03/20	2023/03/20	2023/03/20	2023/03/21	2023/03/21	Average values 2022	Average values 2022		median 2000-2020
		Own sampling	Own sampling	Own sampling	Own sampling	Own sampling	(Ragn-Sells, 2022); (Footnote 4)	(Ragn-Sells, 2022); (Footnote 4)	(Öman et al. 2000, Average values from Table 5.1 in Bilaga 5)	(Norrvatten, 2021b)
Calcium, Ca	mg/L	90.1	69.3	44.1	110	122	67	214	110	26
Iron, Fe	mg/L	0.00239	0.0075	0.159	0.31	0.366	0.5	0.7	7.2	0.073

Magnesium, Mg	mg/L	22.2	22.1	10.7	8.36	14.8	7.5	50.2	42	4.8
Arsenic, As	µg/L	0.26	0.27	0.45	0.56	1.21	0.3	1.2	3.8	0.52
Cadmium, Cd	µg/L	0.043	0.134	0.0401	0.029	0.0371	0.02	0.09	0.3	0.004
Copper, Cu	µg/L	5.16	4.51	7.6	0.839	0.97	0.05	0.07	22	2.2
Manganese, Mn	µg/L	139	361	23.7	519	62.6	83.8	456	1260	14
Lead, Pb	µg/L	0.01	0.01	0.245	0.124	0.65	0.006	0.006	4.9	0.087
Water Hardness	°dH	17.7	14.8	8.64	17.3	20.5	11	41	41.7[5]	3.7
Ammonia & ammonium as NH4	mg/L	0.05	0.072	0.05	0.92	0.05	0.13	0.40	481	0.013
Phosphate, PO4	mg/L	0.04	0.04	0.124	20.9	0.048	0.031	0.031	3.41	0.05
Nitrate, NO3	mg/L	17.3	14.8	7.78	10.7	10.8	0.044	5.72	1.51[6]	1
Fluoride, F	mg/L	0.79	0.66	0.5	0.2	0.41	0.22	0.33	11	0.28
Chloride, Cl	mg/L	101	65.4	20.8	35.2	229	7.5	656	1730	16
Sulphate, SO4	mg/L	87.2	118	42.3	0.9	91	14.8	287	180	24
Conductivity	mS/m	94.7	77.4	39.8	103	124	40	286	1210	22.9
pH		7.2	7	7	7.8	7.4	8	8	7.5	7.8
Alkalinity	mg HCO3-/L	306	197	139	590	284	228	263	2800	70
TOC	mg/L	3.4	4.4	17	25	7	12	23	260	7.6

[5] (Olofsson, B., n.d.)
[6] (Olofsson, B., n.d.)

*Table 12. The data used to generate PCA **B.***

			PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFBS	PFHxS	PFOS	6:2 FTS
RY202	*24/03/2023*	*Data from Ragn-Sells (footnote 4)*	*2.3*	*1.5*	*0.72*	*0.72*	*0.66*	*0*	*0*	*0.54*	*1.2*	*0.35*	*0*
Y208	*24/03/2023*	*Data from Ragn-Sells (footnote 4)*	*55*	*100*	*150*	*34*	*28*	*0.7*	*0*	*110*	*94*	*21*	*5.2*
Brobäcken	*08/02/2023*	*Own sampling*	*28.0*	*44.0*	*64.0*	*20.0*	*18.0*	*0.6*	*0.0*	*44.0*	*62.0*	*24.0*	*1.8*
EY2301	*20/03/2023*	*Own sampling*	*12.8*	*35.7*	*19.8*	*13.2*	*11.0*	*0.0*	*0.0*	*3.3*	*6.9*	*9.2*	*0.0*
EY2302	*20/03/2023*	*Own sampling*	*6.2*	*17.2*	*9.1*	*6.4*	*6.5*	*0.0*	*0.0*	*2.2*	*3.8*	*4.7*	*0.0*
EY2308	*20/03/2023*	*Own sampling*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.5*	*0.0*
SYV2309	*21/03/2023*	*Own sampling*	*0.0*	*0.0*	*17.9*	*11.3*	*34.1*	*6.6*	*5.0*	*4.6*	*0.0*	*13.2*	*0.0*
SYV2305	*21/03/2023*	*Own sampling*	*17.6*	*68.6*	*38.3*	*17.9*	*11.9*	*1.9*	*2.3*	*3.7*	*6.1*	*21.3*	*12.8*
Raw water Norrvatten	*Median 2022*	*PFAS data Norrvatten*	*1.85*	*1.1*	*1.2*	*0.705*	*1.1*	*0.23*	*0*	*0.74*	*0.74*	*2*	*0*
Leachate	*ID 136 Lakvatten (available in the reports raw data file)*	*(Miljösamverkan Sverige, 2022)*	*250*	*130*	*87*	*35*	*74*	*4.1*	*1.7*	*9*	*6.3*	*68*	*0*
Sewage Water	*Measurements carried out at the Bergkvara sewage treatment plant in 2017*	*(Haglund, 2018)*	*0*	*0*	*3.05*	*1.61*	*4.1*	*0.48*	*0.41*	*0.88*	*5.65*	*11.64*	*0*
Precipitation	*Measurements (median) carried out in Perkinstown (2020 from April-July)*	*(Pfotenhauer et al., 2022)*	*0.3*	*0.13*	*0.27*	*0.19*	*0.16*	*0.1*	*0.07*	*0*	*0.21*	*0.26*	*0.04*

D The Inventory of Landfills Within the Östra Mälaren Water Protection Area

Please view the excel file accompanying this report.

E The Water Physico-Chemical Parameters and the PFAS Detected in the Field Work Water Samples

Analyscertifikat

Ordernummer	:	**ST2309715**	Sida	:	1 av 27
Kund	:	**Niras Sweden AB**	Projekt	:	PFAS Östra Mälaren
Kontaktperson	:	Matilda Schütz	Beställningsnummer	:	32402320-001, Matilda Schütz
Adress	:	Box 761 601 17 Norrköping Sverige	Provtagare Provtagningspunkt Ankomstdatum, prover	: : :	---- ---- 2023-03-27 15:15
E-post	:	matilda.schutz@niras.se	Analys påbörjad	:	2023-04-04
Telefon	:	----	Utfärdad	:	2023-04-14 16:17
C-O-C-nummer (eller Orderblankett-nummer)	:	----	Antal ankomna prover	:	25
Offertnummer	:	ST2021SE-NIR-SWE0001 (OF210090)	Antal analyserade prover	:	25

Generell kommentar

Denna rapport får endast återges i sin helhet, om inte utfärdande laboratorium i förväg skriftligen godkänt annat. Resultatet gäller endast materialet såsom det har mottagits, identifierats och testats. Laboratoriet tar inget ansvar för information i denna rapport som har lämnats av kunden, eller resultat som kan ha påverkats av sådan information. Beträffande laboratoriets ansvar i samband med uppdrag, se vår webbplats www.alsglobal.se

Orderkommentar

-

Signatur	*Position*
Niels-Kristian Terkildsen	Laboratoriechef

Analysresultat

Matris: **VATTEN**	*Provbeteckning*	**EYV2301**					
	Laboratoriets provnummer	*ST2309715-001*					
	Provtagningsdatum / tid	*2023-03-27*					
Parameter	**Resultat**	MU	*Enhet*	*LOR*	*Analyspaket*	*Metod*	*Utf.*
Perfluorerade ämnen							
perfluorbutansyra (PFBA)	0.0128	± 0.005	µg/L	0.0020	OV-34aQ	W-PFCLMS03	PR
perfluoropentansyra (PFPeA)	0.0357	± 0.01	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluorhexansyra (PFHxA)	0.0198	± 0.008	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluoroheptansyra (PFHpA)	0.0132	± 0.005	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluoroktansyra (PFOA)	0.0110	± 0.004	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluorononansyra (PFNA)	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluorodekansyra (PFDA)	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluorbutansulfonsyra (PFBS)	0.00325	± 0.001	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluorhexansulfonsyra (PFHxS)	0.00693	± 0.003	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluoroktansulfonsyra (PFOS)	0.00922	± 0.004	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
6:2 FTS fluortelomersulfonat	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
summa PFAS 11	0.112	± 0.04	µg/L	0.00250	OV-34aQ	W-PFCLMS03	PR
summa PFAS 4	0.0272	± 0.01	µg/L	0.00060	OV-34aQ	W-PFCLMS03	PR
perfluorundekansyra (PFUnDA)	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluorododekansyra (PFDoDA)	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
PFTrDA perfluortridekansyra	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
PFPeS perfluorpentansulfonsyra	0.00167	± 0.0007	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluoroheptansulfonsyra (PFHpS)	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
PFNS perfluornonansulfonsyra	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluorodekan sulfonsyra (PFDS)	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluorundekansulfonsyra (PFUnDS)	<0.0040	----	µg/L	0.0010	OV-34aQ	W-PFCLMS03	PR
PFDoDS perfluordodekansulfonsyra	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
PFTrDS perfluortridekansulfonsyra	<0.0040	----	µg/L	0.0010	OV-34aQ	W-PFCLMS03	PR
summa PFAS 20 (2020/2184)	0.114	± 0.04	µg/L	0.00455	OV-34aQ	W-PFCLMS03	PR
summa PFAS 21	0.114	± 0.04	µg/L	0.00470	OV-34aQ	W-PFCLMS03	PR
4:2 FTS fluortelomersulfonat	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
8:2 FTS fluortelomersulfonat	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluoroktan-sulfonamid (FOSA)	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
N-metylperfluoroktansulfonamid (MeFOSA)	<0.0080	----	µg/L	0.0020	OV-34aQ	W-PFCLMS03	PR
N-etylperfluoroktansulfonamid (EtFOSA)	<0.0080	----	µg/L	0.0020	OV-34aQ	W-PFCLMS03	PR
N-metylperfluoroktansulfonamidetanol (MeFOSE)	<0.0080	----	µg/L	0.0020	OV-34aQ	W-PFCLMS03	PR
N-etylperfluoroktansulfonamidetanol (EtFOSE)	<0.0080	----	µg/L	0.0020	OV-34aQ	W-PFCLMS03	PR
FOSAA perfluoroktansulfonamidättiksyra	<0.0040	----	µg/L	0.0010	OV-34aQ	W-PFCLMS03	PR
N-metylperfluoroktansulfonamidättiksyra (MeFOSAA)	<0.0040	----	µg/L	0.0010	OV-34aQ	W-PFCLMS03	PR
N-etylperfluoroktansulfonamidättiksyra (EtFOSAA)	<0.0040	----	µg/L	0.0010	OV-34aQ	W-PFCLMS03	PR
7H-perfluorheptansyra (HPFHpA)	<0.0040	----	µg/L	0.0010	OV-34aQ	W-PFCLMS03	PR
PF37DMOA perfluor-3,7-dimetyloktansyra	<0.0040	----	µg/L	0.0010	OV-34aQ	W-PFCLMS03	PR
PFTeDA perfluortetradekansyra	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR

Matris: **VATTEN**

	Provbeteckning	EYV2302					
	Laboratoriets provnummer	ST2309715-002					
	Provtagningsdatum / tid	2023-03-27					
Parameter	**Resultat**	MU	*Enhet*	*LOR*	*Analyspaket*	*Metod*	*Utf.*
Perfluorerade ämnen							
perfluorbutansyra (PFBA)	0.0062	± 0.002	µg/L	0.0020	OV-34aQ	W-PFCLMS03	PR
perfluoropentansyra (PFPeA)	0.0172	± 0.007	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluorhexansyra (PFHxA)	0.00911	± 0.004	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluoroheptansyra (PFHpA)	0.00642	± 0.002	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluoroktansyra (PFOA)	0.00652	± 0.003	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluorononansyra (PFNA)	<0.00030	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluorodekansyra (PFDA)	<0.00030	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluorbutansulfonsyra (PFBS)	0.00223	± 0.0009	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluorhexansulfonsyra (PFHxS)	0.00381	± 0.002	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluoroktansulfonsyra (PFOS)	0.00465	± 0.002	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
6:2 FTS fluortelomersulfonat	<0.00030	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
summa PFAS 11	0.0561	± 0.02	µg/L	0.00250	OV-34aQ	W-PFCLMS03	PR
summa PFAS 4	0.0150	± 0.006	µg/L	0.00060	OV-34aQ	W-PFCLMS03	PR
perfluorundekansyra (PFUnDA)	<0.00030	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluorododekansyra (PFDoDA)	<0.00030	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
PFTrDA perfluortridekansyra	<0.00030	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
PFPeS perfluorpentansulfonsyra	0.00099	± 0.0004	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluoroheptansulfonsyra (PFHpS)	<0.00030	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
PFNS perfluornonansulfonsyra	<0.00030	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluorodekan sulfonsyra (PFDS)	<0.00030	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluorundekansulfonsyra (PFUnDS)	<0.0010	----	µg/L	0.0010	OV-34aQ	W-PFCLMS03	PR
PFDoDS perfluordodekansulfonsyra	<0.00030	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
PFTrDS perfluortridekansulfonsyra	<0.0010	----	µg/L	0.0010	OV-34aQ	W-PFCLMS03	PR
summa PFAS 20 (2020/2184)	0.0571	± 0.02	µg/L	0.00455	OV-34aQ	W-PFCLMS03	PR
summa PFAS 21	0.0571	± 0.02	µg/L	0.00470	OV-34aQ	W-PFCLMS03	PR
4:2 FTS fluortelomersulfonat	<0.00030	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
8:2 FTS fluortelomersulfonat	<0.00030	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluoroktan-sulfonamid (FOSA)	<0.00030	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
N-metylperfluoroktansulfonamid (MeFOSA)	<0.0020	----	µg/L	0.0020	OV-34aQ	W-PFCLMS03	PR
N-etylperfluoroktansulfonamid (EtFOSA)	<0.0020	----	µg/L	0.0020	OV-34aQ	W-PFCLMS03	PR
N-metylperfluoroktansulfonamidetanol (MeFOSE)	<0.0020	----	µg/L	0.0020	OV-34aQ	W-PFCLMS03	PR
N-etylperfluoroktansulfonamidetanol (EtFOSE)	<0.0020	----	µg/L	0.0020	OV-34aQ	W-PFCLMS03	PR
FOSAA perfluoroktansulfonamidättiksyra	<0.0010	----	µg/L	0.0010	OV-34aQ	W-PFCLMS03	PR
N-metylperfluoroktansulfonamidättiksyra (MeFOSAA)	<0.0010	----	µg/L	0.0010	OV-34aQ	W-PFCLMS03	PR
N-etylperfluoroktansulfonamidättiksyra (EtFOSAA)	<0.0010	----	µg/L	0.0010	OV-34aQ	W-PFCLMS03	PR
7H-perfluorheptansyra (HPFHpA)	<0.0010	----	µg/L	0.0010	OV-34aQ	W-PFCLMS03	PR
PF37DMOA perfluor-3,7-dimetyloktansyra	<0.0010	----	µg/L	0.0010	OV-34aQ	W-PFCLMS03	PR
PFTeDA perfluortetradekansyra	<0.00030	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR

Matris: **VATTEN**

	Provbeteckning	**EYV2308**
	Laboratoriets provnummer	*ST2309715-008*
	Provtagningsdatum / tid	*2023-03-27*

Parameter	**Resultat**	MU	*Enhet*	*LOR*	*Analyspaket*	*Metod*	*Utf.*
Perfluorerade ämnen							
perfluorbutansyra (PFBA)	<0.0040	----	µg/L	0.0020	OV-34aQ	W-PFCLMS03	PR
perfluoropentansyra (PFPeA)	<0.00390	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluorhexansyra (PFHxA)	<0.00030	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluoroheptansyra (PFHpA)	<0.00030	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluoroktansyra (PFOA)	<0.00030	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluorononansyra (PFNA)	<0.00030	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluorodekansyra (PFDA)	<0.00030	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluorbutansulfonsyra (PFBS)	<0.00030	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluorhexansulfonsyra (PFHxS)	<0.00030	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluoroktansulfonsyra (PFOS)	0.00049	± 0.0002	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
6:2 FTS fluortelomersulfonat	<0.00030	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
summa PFAS 11	0.00049	± 0.0002	µg/L	0.00250	OV-34aQ	W-PFCLMS03	PR
summa PFAS 4	0.00049	± 0.0002	µg/L	0.00060	OV-34aQ	W-PFCLMS03	PR
perfluorundekansyra (PFUnDA)	<0.00030	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluorododekansyra (PFDoDA)	<0.00030	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
PFTrDA perfluortridekansyra	<0.00030	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
PFPeS perfluorpentansulfonsyra	<0.00030	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluoroheptansulfonsyra (PFHpS)	<0.00030	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
PFNS perfluornonansulfonsyra	<0.00030	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluorodekan sulfonsyra (PFDS)	<0.00030	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluorundekansulfonsyra (PFUnDS)	<0.0010	----	µg/L	0.0010	OV-34aQ	W-PFCLMS03	PR
PFDoDS perfluordodekansulfonsyra	<0.00030	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
PFTrDS perfluortridekansulfonsyra	<0.0010	----	µg/L	0.0010	OV-34aQ	W-PFCLMS03	PR
summa PFAS 20 (2020/2184)	0.00049	± 0.0002	µg/L	0.00455	OV-34aQ	W-PFCLMS03	PR
summa PFAS 21	0.00049	± 0.0002	µg/L	0.00470	OV-34aQ	W-PFCLMS03	PR
4:2 FTS fluortelomersulfonat	<0.00030	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
8:2 FTS fluortelomersulfonat	<0.00030	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluoroktan-sulfonamid (FOSA)	<0.00030	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
N-metylperfluoroktansulfonamid (MeFOSA)	<0.0020	----	µg/L	0.0020	OV-34aQ	W-PFCLMS03	PR
N-etylperfluoroktansulfonamid (EtFOSA)	<0.0020	----	µg/L	0.0020	OV-34aQ	W-PFCLMS03	PR
N-metylperfluoroktansulfonamidetanol (MeFOSE)	<0.0020	----	µg/L	0.0020	OV-34aQ	W-PFCLMS03	PR
N-etylperfluoroktansulfonamidetanol (EtFOSE)	<0.0020	----	µg/L	0.0020	OV-34aQ	W-PFCLMS03	PR
FOSAA perfluoroktansulfonamidättiksyra	<0.0010	----	µg/L	0.0010	OV-34aQ	W-PFCLMS03	PR
N-metylperfluoroktansulfonamidättiksyra (MeFOSAA)	<0.0010	----	µg/L	0.0010	OV-34aQ	W-PFCLMS03	PR
N-etylperfluoroktansulfonamidättiksyra (EtFOSAA)	<0.0010	----	µg/L	0.0010	OV-34aQ	W-PFCLMS03	PR
7H-perfluorheptansyra (HPFHpA)	<0.0010	----	µg/L	0.0010	OV-34aQ	W-PFCLMS03	PR
PF37DMOA perfluor-3,7-dimetyloktansyra	<0.0010	----	µg/L	0.0010	OV-34aQ	W-PFCLMS03	PR
PFTeDA perfluortetradekansyra	<0.00030	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR

Matris: **VATTEN**		*Provbeteckning*	**SYV2305**					
		Laboratoriets provnummer	*ST2309715-013*					
		Provtagningsdatum / tid	*2023-03-27*					
Parameter	**Resultat**	MU	*Enhet*	*LOR*	*Analyspaket*	*Metod*	*Utf.*	
Perfluorerade ämnen								
perfluorbutansyra (PFBA)	0.0176	± 0.007	µg/L	0.0020	OV-34aQ	W-PFCLMS03	PR	
perfluoropentansyra (PFPeA)	0.0686	± 0.03	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR	
perfluorhexansyra (PFHxA)	0.0383	± 0.02	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR	
perfluoroheptansyra (PFHpA)	0.0179	± 0.007	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR	
perfluoroktansyra (PFOA)	0.0119	± 0.005	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR	
perfluorononansyra (PFNA)	0.00194	± 0.0008	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR	
perfluorodekansyra (PFDA)	0.00225	± 0.0009	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR	
perfluorbutansulfonsyra (PFBS)	0.00372	± 0.001	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR	
perfluorhexansulfonsyra (PFHxS)	0.00607	± 0.002	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR	
perfluoroktansulfonsyra (PFOS)	0.0213	± 0.008	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR	
6:2 FTS fluortelomersulfonat	0.0128	± 0.005	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR	
summa PFAS 11	0.202	± 0.08	µg/L	0.00250	OV-34aQ	W-PFCLMS03	PR	
summa PFAS 4	0.0412	± 0.02	µg/L	0.00060	OV-34aQ	W-PFCLMS03	PR	
perfluorundekansyra (PFUnDA)	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR	
perfluorododekansyra (PFDoDA)	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR	
PFTrDA perfluortridekansyra	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR	
PFPeS perfluorpentansulfonsyra	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR	
perfluoroheptansulfonsyra (PFHpS)	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR	
PFNS perfluornonansulfonsyra	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR	
perfluorodekan sulfonsyra (PFDS)	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR	
perfluorundekansulfonsyra (PFUnDS)	<0.0040	----	µg/L	0.0010	OV-34aQ	W-PFCLMS03	PR	
PFDoDS perfluordodekansulfonsyra	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR	
PFTrDS perfluortridekansulfonsyra	<0.0040	----	µg/L	0.0010	OV-34aQ	W-PFCLMS03	PR	
summa PFAS 20 (2020/2184)	0.190	± 0.08	µg/L	0.00455	OV-34aQ	W-PFCLMS03	PR	
summa PFAS 21	0.202	± 0.08	µg/L	0.00470	OV-34aQ	W-PFCLMS03	PR	
4:2 FTS fluortelomersulfonat	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR	
8:2 FTS fluortelomersulfonat	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR	
perfluoroktan-sulfonamid (FOSA)	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR	
N-metylperfluoroktansulfonamid (MeFOSA)	<0.0080	----	µg/L	0.0020	OV-34aQ	W-PFCLMS03	PR	
N-etylperfluoroktansulfonamid (EtFOSA)	<0.0080	----	µg/L	0.0020	OV-34aQ	W-PFCLMS03	PR	
N-metylperfluoroktansulfonamidetanol (MeFOSE)	<0.0080	----	µg/L	0.0020	OV-34aQ	W-PFCLMS03	PR	
N-etylperfluoroktansulfonamidetanol (EtFOSE)	<0.0080	----	µg/L	0.0020	OV-34aQ	W-PFCLMS03	PR	
FOSAA perfluoroktansulfonamidättiksyra	<0.0040	----	µg/L	0.0010	OV-34aQ	W-PFCLMS03	PR	
N-metylperfluoroktansulfonamidättiksyra (MeFOSAA)	<0.0040	----	µg/L	0.0010	OV-34aQ	W-PFCLMS03	PR	
N-etylperfluoroktansulfonamidättiksyra (EtFOSAA)	<0.0040	----	µg/L	0.0010	OV-34aQ	W-PFCLMS03	PR	
7H-perfluorheptansyra (HPFHpA)	<0.0040	----	µg/L	0.0010	OV-34aQ	W-PFCLMS03	PR	
PF37DMOA perfluor-3,7-dimetyloktansyra	<0.0040	----	µg/L	0.0010	OV-34aQ	W-PFCLMS03	PR	
PFTeDA perfluortetradekansyra	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR	

Matris: VATTEN	Provbeteckning	SYV2309					
	Laboratoriets provnummer	ST2309715-016					
	Provtagningsdatum / tid	2023-03-27					
Parameter	Resultat	MU	Enhet	LOR	Analyspaket	Metod	Utf.
Perfluorerade ämnen							
perfluorbutansyra (PFBA)	<0.0560	----	µg/L	0.0020	OV-34aQ	W-PFCLMS03	PR
perfluoropentansyra (PFPeA)	<0.0840	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluorhexansyra (PFHxA)	0.0179	± 0.007	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluoroheptansyra (PFHpA)	0.0113	± 0.004	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluoroktansyra (PFOA)	0.0341	± 0.01	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluorononansyra (PFNA)	0.00656	± 0.003	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluorodekansyra (PFDA)	0.00500	± 0.002	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluorbutansulfonsyra (PFBS)	0.00457	± 0.002	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluorhexansulfonsyra (PFHxS)	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluoroktansulfonsyra (PFOS)	0.0132	± 0.005	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
6:2 FTS fluortelomersulfonat	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
summa PFAS 11	0.0926	± 0.04	µg/L	0.00250	OV-34aQ	W-PFCLMS03	PR
summa PFAS 4	0.0539	± 0.02	µg/L	0.00060	OV-34aQ	W-PFCLMS03	PR
perfluorundekansyra (PFUnDA)	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluorododekansyra (PFDoDA)	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
PFTrDA perfluortridekansyra	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
PFPeS perfluorpentansulfonsyra	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluoroheptansulfonsyra (PFHpS)	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
PFNS perfluornonansulfonsyra	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluorodekan sulfonsyra (PFDS)	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluorundekansulfonsyra (PFUnDS)	<0.0040	----	µg/L	0.0010	OV-34aQ	W-PFCLMS03	PR
PFDoDS perfluordodekansulfonsyra	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
PFTrDS perfluortridekansulfonsyra	<0.0040	----	µg/L	0.0010	OV-34aQ	W-PFCLMS03	PR
summa PFAS 20 (2020/2184)	0.0926	± 0.04	µg/L	0.00455	OV-34aQ	W-PFCLMS03	PR
summa PFAS 21	0.0926	± 0.04	µg/L	0.00470	OV-34aQ	W-PFCLMS03	PR
4:2 FTS fluortelomersulfonat	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
8:2 FTS fluortelomersulfonat	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
perfluoroktan-sulfonamid (FOSA)	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR
N-metylperfluoroktansulfonamid (MeFOSA)	<0.0080	----	µg/L	0.0020	OV-34aQ	W-PFCLMS03	PR
N-etylperfluoroktansulfonamid (EtFOSA)	<0.0080	----	µg/L	0.0020	OV-34aQ	W-PFCLMS03	PR
N-metylperfluoroktansulfonamidetanol (MeFOSE)	<0.0080	----	µg/L	0.0020	OV-34aQ	W-PFCLMS03	PR
N-etylperfluoroktansulfonamidetanol (EtFOSE)	<0.0080	----	µg/L	0.0020	OV-34aQ	W-PFCLMS03	PR
FOSAA perfluoroktansulfonamidättiksyra	<0.0040	----	µg/L	0.0010	OV-34aQ	W-PFCLMS03	PR
N-metylperfluoroktansulfonamidättiksyra (MeFOSAA)	<0.0040	----	µg/L	0.0010	OV-34aQ	W-PFCLMS03	PR
N-etylperfluoroktansulfonamidättiksyra (EtFOSAA)	<0.0040	----	µg/L	0.0010	OV-34aQ	W-PFCLMS03	PR
7H-perfluorheptansyra (HPFHpA)	<0.0040	----	µg/L	0.0010	OV-34aQ	W-PFCLMS03	PR
PF37DMOA perfluor-3,7-dimetyloktansyra	<0.0040	----	µg/L	0.0010	OV-34aQ	W-PFCLMS03	PR
PFTeDA perfluortetradekansyra	<0.00120	----	µg/L	0.00030	OV-34aQ	W-PFCLMS03	PR

Metodsammanfattningar

Analysmetoder	*Metod*
W-PFCLMS02	Bestämning av perfluorerade ämnen enligt metod baserad på US EPA 537 och CSN P CEN/TS 15968. PFOS, PFHxS och PFOSA; Summan grenade och linjära rapporteras. Mätning utförs med LC-MS-MS. Provet homogeniseras innan upparbetning. Om extraktet innehåller partiklar, filtreras det innan det injiceras i instrumentet. PFAS, summa 11 består av PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFBS, PFHxS, PFOS och 6:2 FTS. Resultat som är "mindre än" (<) ingår inte i summeringen. Resultat "mindre än" (<) betyder ej detekterbart för PFAS summa 11.
W-PFCLMS03	Bestämning av perfluorerade ämnen med låg rapporteringsgräns. enligt metod baserad på US EPA 537 och CSN P CEN/TS 15968. PFOS, PFHxS och PFOSA; Summan grenade och linjära rapporteras. Mätning utförs med LC-MS-MS. Provet homogeniseras innan upparbetning. Om extraktet innehåller partiklar, filtreras det innan det injiceras i instrumentet. PFAS, summa 11 består av PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFBS, PFHxS, PFOS och 6:2 FTS. Resultat som är "mindre än" (<) ingår inte i summeringen. Resultat "mindre än" (<) betyder ej detekterbart för PFAS summa 11.

Nyckel: **LOR** = Den rapporteringsgräns (LOR) som anges är standard för respektive parameter i metoden. Rapporteringsgränsen kan påverkas vid t.ex. spädning p.g.a. matrisstörningar, begränsad provmängd eller låg torrsubstanshalt.

MU = Mätosäkerhet

***** = Asterisk efter resultatet visar på ej ackrediterat test, gäller både egna lab och underleverantör

Mätosäkerhet:

Mätosäkerheten anges som en utvidgad osäkerhet (enligt definitionen i "Evaluation of measurement data- Guide to the expression of uncertainty in measurement", JCGM 100:2008 Corrected version 2010) beräknad med täckningsfaktor lika med 2 vilket ger en konfidensnivå på ungefär 95%.
Mätosäkerhet anges endast för detekterade ämnen med halter över rapporteringsgränsen.

Mätosäkerhet från underleverantör anges oftast som en utvidgad osäkerhet beräknad med täckningsfaktor 2. För ytterligare information kontakta laboratoriet.

Utförande laboratorium (teknisk enhet inom ALS Scandinavia eller anlitat laboratorium (underleverantör)).

	Utf.
PR	*Analys utförd av* ALS Czech Republic s.r.o Prag, Na Harfe 336/9 Prag Tjeckien 190 00 Ackrediterad av: CAI Ackrediteringsnummer: 1163, CSN EN ISO/IEC 17025:2018

Analyscertifikat

Ordernummer	: **ST2308878**	Sida	: 1 av 5
Kund	: **Norrvatten**	Projekt	: Fokus på PFAS
Kontaktperson	: Helene Ejhed	Beställningsnummer	: ----
Adress	: Vattenverksvägen 20 175 47 Järfälla Sverige	Provtagare Provtagningspunkt Ankomstdatum, prover	: ---- : ---- : 2023-03-21 08:59
E-post	: helene.ejhed@norrvatten.se	Analys påbörjad	: 2023-03-21
Telefon	: ----	Utfärdad	: 2023-03-30 16:31
C-O-C-nummer (eller Orderblankett-nummer)	: ----	Antal ankomna prover	: 3
Offertnummer	: ----	Antal analyserade prover	: 3

Generell kommentar

Denna rapport får endast återges i sin helhet, om inte utfärdande laboratorium i förväg skriftligen godkänt annat. Resultatet gäller endast materialet såsom det har mottagits, identifierats och testats. Laboratoriet tar inget ansvar för information i denna rapport som har lämnats av kunden, eller resultat som kan ha påverkats av sådan information. Beträffande laboratoriets ansvar i samband med uppdrag, se vår webbplats www.alsglobal.se

Signatur	Position
Niels-Kristian Terkildsen	Laboratoriechef

Ackred. nr 2030
Provning
ISO/IEC 17025

Analysresultat

Matris: **GRUNDVATTEN**

Provbeteckning	**Uppst_Skå_EYV2301**
Laboratoriets provnummer	*ST2308878-001*
Provtagningsdatum / tid	*2023-03-20*

Parameter	**Resultat**	MU	*Enhet*	*LOR*	*Analyspaket*	*Metod*	*Utf.*
Provberedning							
Filtrering	Ja	----	-	-	PP-FILTR045	W-PP-filt	LE
Metaller och grundämnen							
Ca, kalcium	90.1	± 11.2	mg/L	0.1	GV-3 Plus	W-AES-1A	LE
Fe, järn	0.00239	± 0.00057	mg/L	0.0004	GV-3 Plus	W-SFMS-5A	LE
K, kalium	9.09	± 1.10	mg/L	0.4	GV-3 Plus	W-AES-1A	LE
Mg, magnesium	22.2	± 2.6	mg/L	0.09	GV-3 Plus	W-AES-1A	LE
Na, natrium	75.6	± 9.1	mg/L	0.1	GV-3 Plus	W-AES-1A	LE
Si, kisel	5.71	± 0.67	mg/L	0.03	GV-3 Plus	W-AES-1A	LE
Al, aluminium	13.3	± 2.0	µg/L	0.2	GV-3 Plus	W-SFMS-5A	LE
As, arsenik	0.256	± 0.033	µg/L	0.05	GV-3 Plus	W-SFMS-5A	LE
Ba, barium	51.9	± 7.7	µg/L	0.01	GV-3 Plus	W-SFMS-5A	LE
Cd, kadmium	0.0430	± 0.0064	µg/L	0.002	GV-3 Plus	W-SFMS-5A	LE
Co, kobolt	1.74	± 0.24	µg/L	0.005	GV-3 Plus	W-SFMS-5A	LE
Cr, krom	0.0914	± 0.0144	µg/L	0.01	GV-3 Plus	W-SFMS-5A	LE
Cu, koppar	5.16	± 0.71	µg/L	0.1	GV-3 Plus	W-SFMS-5A	LE
Hg, kvicksilver	<0.002	----	µg/L	0.002	GV-3 Plus	W-AFS-17V2	LE
Mn, mangan	139	± 18	µg/L	0.03	GV-3 Plus	W-SFMS-5A	LE
Mo, molybden	2.96	± 0.44	µg/L	0.05	GV-3 Plus	W-SFMS-5A	LE
Ni, nickel	6.60	± 0.98	µg/L	0.05	GV-3 Plus	W-SFMS-5A	LE
P, fosfor	7.25	± 1.18	µg/L	1	GV-3 Plus	W-SFMS-5A	LE
Pb, bly	<0.01	----	µg/L	0.01	GV-3 Plus	W-SFMS-5A	LE
Sr, strontium	328	± 46	µg/L	2	GV-3 Plus	W-AES-1A	LE
Zn, zink	5.63	± 0.95	µg/L	0.2	GV-3 Plus	W-SFMS-5A	LE
V, vanadin	0.176	± 0.026	µg/L	0.005	GV-3 Plus	W-SFMS-5A	LE
hårdhet	17.7 *	----	°dH	0.10	GV-3 Plus	W-HARDNESS	LE
Oorganiska parametrar							
nitrit, NO2	<0.010	----	mg/L	0.010	GV-3 Plus	Nitrit-N	ST
nitritkväve, NO2-N	<0.002	----	mg/L	0.002	GV-3 Plus	Nitrit-N	ST
COD-Mn	1.66	± 0.50	mg/L	0.50	GV-3 Plus	W-CODMN-SPC	PR
ammoniak- + ammoniumkväve	<0.040	----	mg/L	0.040	GV-3 Plus	W-NH4-SPC	PR
ammoniak och ammonium som NH4	<0.050	----	mg/L	0.050	GV-3 Plus	W-NH4-SPC	PR
fosfat, PO4	<0.040	----	mg/L	0.040	GV-3 Plus	W-PO4O-SPC	PR
fosfatfosfor, PO4-P	<0.013	----	mg/L	0.013	GV-3 Plus	W-PO4O-SPC	PR
nitrat, NO3	17.3	± 2.60	mg/L	0.50	GV-3 Plus	W-ANI-SCR	PR
nitratkväve, NO3-N	3.92	± 0.59	mg/L	0.10	GV-3 Plus	W-ANI-SCR	PR
fluorid	0.79	± 0.12	mg/L	0.50	GV-3 Plus	W-ANI-SCR	PR
klorid	101	± 15.1	mg/L	0.50	GV-3 Plus	W-ANI-SCR	PR
sulfat, SO4	87.2	± 13.1	mg/L	0.50	GV-3 Plus	W-ANI-SCR	PR
Fysikaliska parametrar							
mättemperatur pH	20.9 *	----	°C	15.0	GV-3 Plus	pH	ST
turbiditet	8.31	± 1.96	FNU	0.20	GV-3 Plus	Turbiditet	ST
konduktivitet	94.7	± 6.8	mS/m	1.0	GV-3 Plus	Konduktivitet	ST
pH	7.2	± 0.2	-	3.0	GV-3 Plus	pH	ST
alkalinitet	306	± 36.7	mg HCO3-/L	1.0	GV-3 Plus	Alkalinitet	ST

Matris: **GRUNDVATTEN**

	Provbeteckning		**Nedst_Skå_EYV2302**				
	Laboratoriets provnummer		*ST2308878-002*				
	Provtagningsdatum / tid		*2023-03-20*				
Parameter	**Resultat**	MU	*Enhet*	*LOR*	*Analyspaket*	*Metod*	*Utf.*
Provberedning							
Filtrering	Ja	----	-	-	PP-FILTR045	W-PP-filt	LE
Metaller och grundämnen							
Ca, kalcium	69.3	± 8.6	mg/L	0.1	GV-3 Plus	W-AES-1A	LE
Fe, järn	0.00750	± 0.00123	mg/L	0.0004	GV-3 Plus	W-SFMS-5A	LE
K, kalium	8.53	± 1.03	mg/L	0.4	GV-3 Plus	W-AES-1A	LE
Mg, magnesium	22.1	± 2.6	mg/L	0.09	GV-3 Plus	W-AES-1A	LE
Na, natrium	52.8	± 6.3	mg/L	0.1	GV-3 Plus	W-AES-1A	LE
Si, kisel	8.70	± 1.01	mg/L	0.03	GV-3 Plus	W-AES-1A	LE
Al, aluminium	26.7	± 4.0	µg/L	0.2	GV-3 Plus	W-SFMS-5A	LE
As, arsenik	0.269	± 0.035	µg/L	0.05	GV-3 Plus	W-SFMS-5A	LE
Ba, barium	32.8	± 4.9	µg/L	0.01	GV-3 Plus	W-SFMS-5A	LE
Cd, kadmium	0.134	± 0.020	µg/L	0.002	GV-3 Plus	W-SFMS-5A	LE
Co, kobolt	4.81	± 0.67	µg/L	0.005	GV-3 Plus	W-SFMS-5A	LE
Cr, krom	0.138	± 0.021	µg/L	0.01	GV-3 Plus	W-SFMS-5A	LE
Cu, koppar	4.51	± 0.62	µg/L	0.1	GV-3 Plus	W-SFMS-5A	LE
Hg, kvicksilver	<0.002	----	µg/L	0.002	GV-3 Plus	W-AFS-17V2	LE
Mn, mangan	361	± 48	µg/L	0.03	GV-3 Plus	W-SFMS-5A	LE
Mo, molybden	1.99	± 0.29	µg/L	0.05	GV-3 Plus	W-SFMS-5A	LE
Ni, nickel	19.0	± 2.8	µg/L	0.05	GV-3 Plus	W-SFMS-5A	LE
P, fosfor	8.30	± 1.36	µg/L	1	GV-3 Plus	W-SFMS-5A	LE
Pb, bly	<0.01	----	µg/L	0.01	GV-3 Plus	W-SFMS-5A	LE
Sr, strontium	275	± 39	µg/L	2	GV-3 Plus	W-AES-1A	LE
Zn, zink	14.1	± 2.4	µg/L	0.2	GV-3 Plus	W-SFMS-5A	LE
V, vanadin	0.229	± 0.034	µg/L	0.005	GV-3 Plus	W-SFMS-5A	LE
hårdhet	14.8 *	----	°dH	0.10	GV-3 Plus	W-HARDNESS	LE
Oorganiska parametrar							
nitrit, NO2	0.054	± 0.011	mg/L	0.010	GV-3 Plus	Nitrit-N	ST
nitritkväve, NO2-N	0.016	± 0.003	mg/L	0.002	GV-3 Plus	Nitrit-N	ST
COD-Mn	2.46	± 0.74	mg/L	0.50	GV-3 Plus	W-CODMN-SPC	PR
ammoniak- + ammoniumkväve	0.056	± 0.008	mg/L	0.040	GV-3 Plus	W-NH4-SPC	PR
ammoniak och ammonium som NH4	0.072	± 0.011	mg/L	0.050	GV-3 Plus	W-NH4-SPC	PR
fosfat, PO4	<0.040	----	mg/L	0.040	GV-3 Plus	W-PO4O-SPC	PR
fosfatfosfor, PO4-P	<0.013	----	mg/L	0.013	GV-3 Plus	W-PO4O-SPC	PR
nitrat, NO3	14.8	± 2.22	mg/L	0.50	GV-3 Plus	W-ANI-SCR	PR
nitratkväve, NO3-N	3.35	± 0.50	mg/L	0.10	GV-3 Plus	W-ANI-SCR	PR
fluorid	0.66	± 0.10	mg/L	0.50	GV-3 Plus	W-ANI-SCR	PR
klorid	65.4	± 9.81	mg/L	0.50	GV-3 Plus	W-ANI-SCR	PR
sulfat, SO4	118	± 17.8	mg/L	0.50	GV-3 Plus	W-ANI-SCR	PR
Fysikaliska parametrar							
mättemperatur pH	21.0 *	----	°C	15.0	GV-3 Plus	pH	ST
turbiditet	20.1	± 4.67	FNU	0.20	GV-3 Plus	Turbiditet	ST
konduktivitet	77.4	± 5.6	mS/m	1.0	GV-3 Plus	Konduktivitet	ST
pH	7.0	± 0.2	-	3.0	GV-3 Plus	pH	ST
alkalinitet	197	± 23.7	mg HCO3-/L	1.0	GV-3 Plus	Alkalinitet	ST

Matris: **GRUNDVATTEN**		*Provbeteckning*		**Nedst_Svartsjö_EYV2308**			
		Laboratoriets provnummer		*ST2308878-003*			
		Provtagningsdatum / tid		*2023-03-20*			
Parameter	**Resultat**	MU	*Enhet*	*LOR*	*Analyspaket*	*Metod*	*Utf.*
Provberedning							
Filtrering	Ja	----	-	-	PP-FILTR045	W-PP-filt	LE
Metaller och grundämnen							
Ca, kalcium	44.1	± 5.5	mg/L	0.1	GV-3 Plus	W-AES-1A	LE
Fe, järn	0.159	± 0.024	mg/L	0.0004	GV-3 Plus	W-SFMS-5A	LE
K, kalium	6.74	± 0.82	mg/L	0.4	GV-3 Plus	W-AES-1A	LE
Mg, magnesium	10.7	± 1.3	mg/L	0.09	GV-3 Plus	W-AES-1A	LE
Na, natrium	21.7	± 2.6	mg/L	0.1	GV-3 Plus	W-AES-1A	LE
Si, kisel	7.83	± 0.91	mg/L	0.03	GV-3 Plus	W-AES-1A	LE
Al, aluminium	84.6	± 12.6	µg/L	0.2	GV-3 Plus	W-SFMS-5A	LE
As, arsenik	0.446	± 0.056	µg/L	0.05	GV-3 Plus	W-SFMS-5A	LE
Ba, barium	12.9	± 1.9	µg/L	0.01	GV-3 Plus	W-SFMS-5A	LE
Cd, kadmium	0.0401	± 0.0059	µg/L	0.002	GV-3 Plus	W-SFMS-5A	LE
Co, kobolt	0.598	± 0.083	µg/L	0.005	GV-3 Plus	W-SFMS-5A	LE
Cr, krom	0.488	± 0.074	µg/L	0.01	GV-3 Plus	W-SFMS-5A	LE
Cu, koppar	7.60	± 1.04	µg/L	0.1	GV-3 Plus	W-SFMS-5A	LE
Hg, kvicksilver	0.00375	± 0.00064	µg/L	0.002	GV-3 Plus	W-AFS-17V2	LE
Mn, mangan	23.7	± 3.1	µg/L	0.03	GV-3 Plus	W-SFMS-5A	LE
Mo, molybden	1.13	± 0.17	µg/L	0.05	GV-3 Plus	W-SFMS-5A	LE
Ni, nickel	5.38	± 0.80	µg/L	0.05	GV-3 Plus	W-SFMS-5A	LE
P, fosfor	61.3	± 10.0	µg/L	1	GV-3 Plus	W-SFMS-5A	LE
Pb, bly	0.245	± 0.036	µg/L	0.01	GV-3 Plus	W-SFMS-5A	LE
Sr, strontium	133	± 19	µg/L	2	GV-3 Plus	W-AES-1A	LE
Zn, zink	2.82	± 0.48	µg/L	0.2	GV-3 Plus	W-SFMS-5A	LE
V, vanadin	0.763	± 0.112	µg/L	0.005	GV-3 Plus	W-SFMS-5A	LE
hårdhet	8.64 *	----	°dH	0.10	GV-3 Plus	W-HARDNESS	LE
Oorganiska parametrar							
nitrit, NO2	0.012	± 0.005	mg/L	0.010	GV-3 Plus	Nitrit-N	ST
nitritkväve, NO2-N	0.004	± 0.001	mg/L	0.002	GV-3 Plus	Nitrit-N	ST
COD-Mn	9.35	± 2.80	mg/L	0.50	GV-3 Plus	W-CODMN-SPC	PR
ammoniak- + ammoniumkväve	<0.040	----	mg/L	0.040	GV-3 Plus	W-NH4-SPC	PR
ammoniak och ammonium som NH4	<0.050	----	mg/L	0.050	GV-3 Plus	W-NH4-SPC	PR
fosfat, PO4	0.124	± 0.025	mg/L	0.040	GV-3 Plus	W-PO4O-SPC	PR
fosfatfosfor, PO4-P	0.040	± 0.008	mg/L	0.013	GV-3 Plus	W-PO4O-SPC	PR
nitrat, NO3	7.78	± 1.17	mg/L	0.50	GV-3 Plus	W-ANI-SCR	PR
nitratkväve, NO3-N	1.76	± 0.26	mg/L	0.10	GV-3 Plus	W-ANI-SCR	PR
fluorid	<0.50	----	mg/L	0.50	GV-3 Plus	W-ANI-SCR	PR
klorid	20.8	± 3.12	mg/L	0.50	GV-3 Plus	W-ANI-SCR	PR
sulfat, SO4	42.3	± 6.35	mg/L	0.50	GV-3 Plus	W-ANI-SCR	PR
Fysikaliska parametrar							
mättemperatur pH	21.0 *	----	°C	15.0	GV-3 Plus	pH	ST
turbiditet	109	± 25.1	FNU	0.20	GV-3 Plus	Turbiditet	ST
konduktivitet	39.8	± 3.0	mS/m	1.0	GV-3 Plus	Konduktivitet	ST
pH	7.0	± 0.2	-	3.0	GV-3 Plus	pH	ST
alkalinitet	139	± 16.6	mg HCO3-/L	1.0	GV-3 Plus	Alkalinitet	ST

Metodsammanfattningar

Analysmetoder	Metod
W-AES-1A	Analys av metaller i sötvatten med ICP-AES enligt SS-EN ISO 11885:2009 och US EPA Method 200.7:1994. Provet är surgjort med 1 ml HNO3 (suprapur) per 100 ml före analys.
W-AFS-17V2	Analys av kvicksilver (Hg) i naturliga vatten med AFS enligt SS-EN ISO 17852:2008. Provet är surgjort med 1 ml HNO3 (suprapur) per 100 ml före analys.
W-HARDNESS*	Beräknad från magnesium och kalcium
W-PP-filt	Filtrering med 0.45µm filter (SE-SOP-0259, SS-EN ISO 5667-3:2018).
W-SFMS-5A	Analys av metaller i sötvatten med ICP-SFMS enligt SS-EN ISO 17294-2:2016 och US EPA Method 200.8:1994. Provet är surgjort med 1 ml HNO3 (suprapur) per 100 ml före analys.
W-ANI-SCR	Bestämning av bromid, fluorid, klorid, nitrit, nitrat samt sulfat med jonkromatografi enligt metod baserad på CSN EN ISO 10304-1. Filtrering av grumliga prover ingår i metoden.
W-CODMN-SPC	Bestämning av kemisk syreförebrukning, CODMn enligt metod baserad på CSN EN ISO 8467 Dekantering av grumliga prover ingår i metoden.
W-NH4-SPC	Spektrofotometrisk bestämning av ammonium, NH4, med låg LOQ enligt metod baserad på CSN EN ISO 11732, CSN EN ISO 13395, SM 4500-NO2, SM-4500-NO3. Filtrering av grumliga prover ingår i metoden.
W-PO4O-SPC	Spektrofotometrisk bestämning av fosfatfosfor enligt metod baserad på CSN EN ISO 6878 och SM 4500-P. Filtrering av grumliga prover ingår i metoden.
Alkalinitet	SS-EN ISO 9963-2, utg. 1 Provet titreras med saltsyra under avdrivande av koldioxid till slutpunkten pH 5.4.
Konduktivitet	Bestämning av konduktivitet enligt SS-EN 27888, utg. 1. korrigerat till 25°C. Tidskänslig analys. Ackrediteringsområde 1-1000 mS/m.
Nitrit-N	Bestämning av nitrit/nitritkväve enligt SS-EN ISO 15923-1:2013, utg. 1 (diskret analys). Grumliga prover dekanteras alternativt filtreras.
pH	Bestämning av pH enligt SS-EN ISO 10523:2012, utg. 1. Tidskänslig analys. Ackrediteringsområde pH 3-11.
Turbiditet	Bestämning av Turbiditet enligt SS EN ISO 7027-1:2016 utg. 1.

Nyckel: **LOR** = Den rapporteringsgräns (LOR) som anges är standard för respektive parameter i metoden. Rapporteringsgränsen kan påverkas vid t.ex. spädning p.g.a. matrisstörningar, begränsad provmängd eller låg torrsubstanshalt.

MU = Mätosäkerhet

***** = Asterisk efter resultatet visar på ej ackrediterat test, gäller både egna lab och underleverantör

Mätosäkerhet:

Mätosäkerheten anges som en utvidgad osäkerhet (enligt definitionen i "Evaluation of measurement data- Guide to the expression of uncertainty in measurement", JCGM 100:2008 Corrected version 2010) beräknad med täckningsfaktor lika med 2 vilket ger en konfidensnivå på ungefär 95%.
Mätosäkerhet anges endast för detekterade ämnen med halter över rapporteringsgränsen.

Mätosäkerhet från underleverantör anges oftast som en utvidgad osäkerhet beräknad med täckningsfaktor 2. För ytterligare information kontakta laboratoriet.

Utförande laboratorium (teknisk enhet inom ALS Scandinavia eller anlitat laboratorium (underleverantör)).

	Utf.
LE	*Analys utförd av* ALS Scandinavia AB, Aurorum 10 Luleå Sverige 977 75 Ackrediterad av: SWEDAC Ackrediteringsnummer: 2030, ISO/IEC 17025
PR	*Analys utförd av* ALS Czech Republic s.r.o Prag, Na Harfe 336/9 Prag Tjeckien 190 00 Ackrediterad av: CAI Ackrediteringsnummer: 1163, CSN EN ISO/IEC 17025:2018
ST	*Analys utförd av* ALS Scandinavia AB, Rinkebyvägen 19C Danderyd Sverige 182 36 Ackrediterad av: SWEDAC Ackrediteringsnummer: 2030, ISO/IEC 17025

Analyscertifikat

Ordernummer	:	**ST2308959-AA**	Sida	:	1 av 4
Kund	:	**Kommunalförbundet Norrvatten**	Projekt	:	Fokus på PFAS
Kontaktperson	:	Helene Ejhed	Beställningsnummer	:	----
Adress	:	PG1297 737 84 FAGERSTA	Provtagare	:	Elsa Hård af Segerstad
			Provtagningspunkt	:	----
			Ankomstdatum, prover	:	2023-03-21 14:00
E-post	:	helene.ejhed@norrvatten.se	Analys påbörjad	:	2023-03-22
Telefon	:	----	Utfärdad	:	2023-04-04 12:45
C-O-C-nummer (eller Orderblankett-nummer)	:	----	Antal ankomna prover	:	1
Offertnummer	:	----	Antal analyserade prover	:	1

Generell kommentar

Denna rapport får endast återges i sin helhet, om inte utfärdande laboratorium i förväg skriftligen godkänt annat. Resultatet gäller endast materialet såsom det har mottagits, identifierats och testats. Laboratoriet tar inget ansvar för information i denna rapport som har lämnats av kunden, eller resultat som kan ha påverkats av sådan information. Beträffande laboratoriets ansvar i samband med uppdrag, se vår webbplats www.alsglobal.se

Orderkommentar

Vattnet var vid provtagningstillfället tjänligt med anmärkning baserat på resultat från en eller flera parametrar.
Bedömning enligt Livsmedelsverkets riktvärden för små dricksvattenanläggningar för privat bruk.

Signatur	*Position*
Niels-Kristian Terkildsen	Laboratoriechef

Ackred. nr 2030
Provning
ISO/IEC 17025

Analysresultat

-

Matris: **VATTEN**

Provbeteckning	**Uppstr_Johanneslund**
Laboratoriets provnummer	*ST2308959001*
Provtagningsdatum / tid	*2023-03-21*

Bedömning enligt Livsmedelsverkets riktvärden för små dricksvattenanläggningar för privat bruk.

Parameter	Resultat	*Enhet*	MU	*LOR*	*Analyspaket*	*Analys påbörjad*	*Metod*	*Utf.*	*Låg gräns*	*Hög gräns*	*Gränsvärde uppfyllt?*
Metaller och grundämnen											
Ca, kalcium	**110**	mg/L	± 14	0.1	DV-5/ST	2023-03-22	W-AES-1A	LE	----	100	Tjänligt med teknisk anmärkning
Mg, magnesium	**8.36**	mg/L	± 0.98	0.10	DV-5/ST	2023-03-22	W-AES-1A	LE	----	30	Tjänligt
Na, natrium	**52.8**	mg/L	± 6.3	0.1	DV-5/ST	2023-03-22	W-AES-1A	LE	----	100	Tjänligt
K, kalium	**126**	mg/L	± 15	0.4	DV-5/ST	2023-03-22	W-AES-1A	LE	----	12	Tjänligt med anmärkning
Fe, järn	**0.310**	mg/L	± 0.047	0.0040	DV-5/ST	2023-03-22	W-SFMS-5A	LE	----	0.5	Tjänligt
Mn, mangan	**0.519**	mg/L	± 0.069	0.00003	DV-5/ST	2023-03-22	W-SFMS-5A	LE	----	0.3	Tjänligt med teknisk och estetisk anmärkning
Cu, koppar	**0.000839**	mg/L	± 0.000118	0.0001	DV-5/ST	2023-03-22	W-SFMS-5A	LE	----	0.2	Tjänligt
Pb, bly	**0.124**	µg/L	± 0.018	0.01	DV-5/ST	2023-03-22	W-SFMS-5A	LE	----	10	Tjänligt
U, uran	**0.225**	µg/L	± 0.034	0.0005	DV-5/ST	2023-03-22	W-SFMS-5A	LE	----	30	Tjänligt
As, arsenik	**0.564**	µg/L	± 0.070	0.05	DV-5/ST	2023-03-22	W-SFMS-5A	LE	----	10	Tjänligt
Cd, kadmium	**0.0290**	µg/L	± 0.0043	0.002	DV-5/ST	2023-03-22	W-SFMS-5A	LE	----	1	Tjänligt
hårdhet	**17.3 ***	°dH	----	0.10	DV-5/ST	2023-03-23	W-HARDNESS	LE	----	14.95	Tjänligt med teknisk anmärkning
Oorganiska parametrar											
nitrit, NO2	**0.489**	mg/L	± 0.076	0.010	DV-5/ST	2023-03-22	Nitrit-N	ST	----	0.5	Tjänligt med teknisk och hälsomässig anmärkning
alkalinitet	**590**	mg HCO3-/L	± 70.8	1.0	DV-5/ST	2023-03-22	Alkalinitet	ST	----	----	-
COD-Mn	**24.5**	mg/L	± 7.34	0.50	DV-5/ST	2023-03-28	W-CODMN-SPC	PR	----	8	Tjänligt med estetisk anmärkning
ammoniak och ammonium som NH4	**0.923**	mg/L	± 0.138	0.050	DV-5/ST	2023-03-22	W-NH4-SPC	PR	----	1.5	Tjänligt med teknisk anmärkning
fosfat, PO4	**20.9**	mg/L	± 4.18	0.040	DV-5/ST	2023-03-23	W-PO4O-SPC	PR	----	0.6	Tjänligt med anmärkning
nitrat, NO3	**10.7**	mg/L	± 1.60	0.50	DV-5/ST	2023-03-24	W-ANI-SCR	PR	----	20	Tjänligt

Parameter	Resultat	Enhet	MU	LOR	Analyspaket	Analys påbörjad	Metod	Utf.	Låg gräns	Hög gräns	Gränsvärde uppfyllt?
Oorganiska parametrar - Fortsatt											
fluorid	<0.20	mg/L	----	0.20	DV-5/ST	2023-03-24	W-ANI-SCR	PR	----	1.3	Tjänligt
klorid	**35.2**	mg/L	± 5.28	0.50	DV-5/ST	2023-03-24	W-ANI-SCR	PR	----	100	Tjänligt
sulfat, SO4	**0.90**	mg/L	± 0.13	0.50	DV-5/ST	2023-03-24	W-ANI-SCR	PR	----	100	Tjänligt
Fysikaliska parametrar											
turbiditet	**4.78**	FNU	± 1.15	0.20	DV-5/ST	2023-03-22	Turbiditet	ST	----	3	Tjänligt med anmärkning
konduktivitet	**103**	mS/m	± 7.4	1.0	DV-5/ST	2023-03-22	Konduktivitet	ST	----	----	-
pH	**7.8**	-	± 0.2	3.0	DV-5/ST	2023-03-22	pH	ST	6.49	10.5	Tjänligt
färg	**21.3**	mgPt/l	± 6.4	2.0	DV-5/ST	2023-03-24	W-COL-SPC	PR	----	30	Tjänligt
Rapport											
bedömning	**Ja**	-	----	-	DV-5/ST	2023-04-04	DV-BED	ST	----	----	-

Metodsammanfattningar

Analysmetoder	Metod
W-AES-1A	Analys av metaller i sötvatten med ICP-AES enligt SS-EN ISO 11885:2009 och US EPA Method 200.7:1994. Provet är surgjort med 1 ml HNO3 (suprapur) per 100 ml före analys.
W-HARDNESS*	Beräknad från magnesium och kalcium
W-SFMS-5A	Analys av metaller i sötvatten med ICP-SFMS enligt SS-EN ISO 17294-2:2016 och US EPA Method 200.8:1994. Provet är surgjort med 1 ml HNO3 (suprapur) per 100 ml före analys.
W-ANI-SCR	Bestämning av bromid, fluorid, klorid, nitrit, nitrat samt sulfat med jonkromatografi enligt metod baserad på CSN EN ISO 10304-1. Filtrering av grumliga prover ingår i metoden.
W-CODMN-SPC	Bestämning av kemisk syreförebrukning, CODMn enligt metod baserad på CSN EN ISO 8467 Dekantering av grumliga prover ingår i metoden.
W-COL-SPC	Spektrofotometrisk bestämning av färg efter filtrering enligt metod CSN EN ISO 7887.
W-NH4-SPC	Spektrofotometrisk bestämning av ammonium, NH4, med låg LOQ enligt metod baserad på CSN EN ISO 11732, CSN EN ISO 13395, SM 4500-NO2, SM-4500-NO3. Filtrering av grumliga prover ingår i metoden.
W-PO4O-SPC	Spektrofotometrisk bestämning av fosfatfosfor enligt metod baserad på CSN EN ISO 6878 och SM 4500-P. Filtrering av grumliga prover ingår i metoden.
Alkalinitet	SS-EN ISO 9963-2, utg. 1 Provet titreras med saltsyra under avdrivande av koldioxid till slutpunkten pH 5.4.
DV-BED	Utgående dricksvatten samt dricksvatten hos användaren bedöms enligt LIVSFS 2022:12 - bilaga 1, reviderad januari 2023. Enskild brunn bedöms enligt Livsmedelsverkets riktvärden för små dricksvattenanläggningar för privat bruk, reviderad december 2022.
Konduktivitet	Bestämning av konduktivitet enligt SS-EN 27888, utg. 1. korrigerat till 25°C. Tidskänslig analys. Ackrediteringsområde 1-1000 mS/m.
Nitrit-N	Bestämning av nitrit/nitritkväve enligt SS-EN ISO 15923-1:2013, utg. 1 (diskret analys). Grumliga prover dekanteras alternativt filtreras.
pH	Bestämning av pH enligt SS-EN ISO 10523:2012, utg. 1. Tidskänslig analys. Ackrediteringsområde pH 3-11.
Turbiditet	Bestämning av Turbiditet enligt SS EN ISO 7027-1:2016 utg. 1.

Nyckel: **LOR** = Den rapporteringsgräns (LOR) som anges är standard för respektive parameter i metoden. Rapporteringsgränsen kan påverkas vid t.ex. spädning p.g.a. matrisstörningar, begränsad provmängd eller låg torrsubstanshalt.

MU = Mätosäkerhet

***** = Asterisk efter resultatet visar på ej ackrediterat test, gäller både egna lab och underleverantör

Mätosäkerhet:

Mätosäkerheten anges som en utvidgad osäkerhet (enligt definitionen i "Evaluation of measurement data- Guide to the expression of uncertainty in measurement", JCGM 100:2008 Corrected version 2010) beräknad med täckningsfaktor lika med 2 vilket ger en konfidensnivå på ungefär 95%.
Mätosäkerhet anges endast för detekterade ämnen med halter över rapporteringsgränsen.

Mätosäkerhet från underleverantör anges oftast som en utvidgad osäkerhet beräknad med täckningsfaktor 2. För ytterligare information kontakta laboratoriet.

Utförande laboratorium (teknisk enhet inom ALS Scandinavia eller anlitat laboratorium (underleverantör)).

	Utf.
LE	*Analys utförd av* ALS Scandinavia AB, Aurorum 10 Luleå Sverige 977 75 Ackrediterad av: SWEDAC Ackrediteringsnummer: 2030, ISO/IEC 17025
PR	*Analys utförd av* ALS Czech Republic s.r.o Prag, Na Harfe 336/9 Prag Tjeckien 190 00 Ackrediterad av: CAI Ackrediteringsnummer: 1163, CSN EN ISO/IEC 17025:2018
ST	*Analys utförd av* ALS Scandinavia AB, Rinkebyvägen 19C Danderyd Sverige 182 36 Ackrediterad av: SWEDAC Ackrediteringsnummer: 2030, ISO/IEC 17025

Analyscertifikat

Ordernummer	: **ST2308959-AB**	Sida	: 1 av 4
Kund	: **Kommunalförbundet Norrvatten**	Projekt	: Fokus på PFAS
Kontaktperson	: Helene Ejhed	Beställningsnummer	: ----
Adress	: PG1297 737 84 FAGERSTA	Provtagare	: Elsa Hård af Segerstad
		Provtagningspunkt	: ----
		Ankomstdatum, prover	: 2023-03-21 14:00
E-post	: helene.ejhed@norrvatten.se	Analys påbörjad	: 2023-03-22
Telefon	: ----	Utfärdad	: 2023-04-04 12:45
C-O-C-nummer (eller Orderblankett-nummer)	: ----	Antal ankomna prover	: 1
Offertnummer	: ----	Antal analyserade prover	: 1

Generell kommentar

Denna rapport får endast återges i sin helhet, om inte utfärdande laboratorium i förväg skriftligen godkänt annat. Resultatet gäller endast materialet såsom det har mottagits, identifierats och testats. Laboratoriet tar inget ansvar för information i denna rapport som har lämnats av kunden, eller resultat som kan ha påverkats av sådan information. Beträffande laboratoriets ansvar i samband med uppdrag, se vår webbplats www.alsglobal.se

Orderkommentar

Vattnet var vid provtagningstillfället tjänligt med anmärkning baserat på resultat från en eller flera parametrar.
Bedömning enligt Livsmedelsverkets riktvärden för små dricksvattenanläggningar för privat bruk.

Signatur	*Position*
Niels-Kristian Terkildsen	Laboratoriechef

Ackred. nr 2030
Provning
ISO/IEC 17025

Analysresultat

-

Matris: **VATTEN**

				Provbeteckning	**Nedstr_Johanneslund_ SYV2305**		**Bedömning enligt Livsmedelsverkets riktvärden för små dricksvattenanläggningar för privat bruk.**					
				Laboratoriets provnummer	*ST2308959002*							
				Provtagningsdatum / tid	*2023-03-21*							
Parameter	Resultat	*Enhet*	MU	*LOR*	*Analyspaket*	*Analys påbörjad*	*Metod*	*Utf.*	*Låg gräns*	*Hög gräns*	*Gränsvärde uppfyllt?*	
Metaller och grundämnen												
Ca, kalcium	**122**	mg/L	± 15	0.1	DV-5/ST	2023-03-22	W-AES-1A	LE	----	100	Tjänligt med teknisk anmärkning	
Mg, magnesium	**14.8**	mg/L	± 1.7	0.10	DV-5/ST	2023-03-22	W-AES-1A	LE	----	30	Tjänligt	
Na, natrium	**137**	mg/L	± 17	0.1	DV-5/ST	2023-03-22	W-AES-1A	LE	----	200	Tjänligt med teknisk anmärkning	
K, kalium	**8.98**	mg/L	± 1.09	0.4	DV-5/ST	2023-03-22	W-AES-1A	LE	----	12	Tjänligt	
Fe, järn	**0.366**	mg/L	± 0.056	0.0040	DV-5/ST	2023-03-22	W-SFMS-5A	LE	----	0.5	Tjänligt	
Mn, mangan	**0.0626**	mg/L	± 0.0083	0.00003	DV-5/ST	2023-03-22	W-SFMS-5A	LE	----	0.3	Tjänligt	
Cu, koppar	**0.00970**	mg/L	± 0.00133	0.0001	DV-5/ST	2023-03-22	W-SFMS-5A	LE	----	0.2	Tjänligt	
Pb, bly	**0.650**	µg/L	± 0.095	0.01	DV-5/ST	2023-03-22	W-SFMS-5A	LE	----	10	Tjänligt	
U, uran	**20.7**	µg/L	± 3.1	0.0005	DV-5/ST	2023-03-22	W-SFMS-5A	LE	----	30	Tjänligt	
As, arsenik	**1.21**	µg/L	± 0.15	0.05	DV-5/ST	2023-03-22	W-SFMS-5A	LE	----	10	Tjänligt	
Cd, kadmium	**0.0371**	µg/L	± 0.0055	0.002	DV-5/ST	2023-03-22	W-SFMS-5A	LE	----	1	Tjänligt	
hårdhet	**20.5 ***	°dH	----	0.10	DV-5/ST	2023-03-23	W-HARDNESS	LE	----	14.95	Tjänligt med teknisk anmärkning	
Oorganiska parametrar												
nitrit, NO2	**0.046**	mg/L	± 0.010	0.010	DV-5/ST	2023-03-22	Nitrit-N	ST	----	0.1	Tjänligt	
alkalinitet	**284**	mg HCO3-/L	± 34.1	1.0	DV-5/ST	2023-03-22	Alkalinitet	ST	----	----	-	
COD-Mn	**3.60**	mg/L	± 1.08	0.50	DV-5/ST	2023-03-28	W-CODMN-SPC	PR	----	8	Tjänligt	
ammoniak och ammonium som NH4	<0.050	mg/L	----	0.050	DV-5/ST	2023-03-22	W-NH4-SPC	PR	----	0.5	Tjänligt	
fosfat, PO4	**0.048**	mg/L	± 0.010	0.040	DV-5/ST	2023-03-23	W-PO4O-SPC	PR	----	0.6	Tjänligt	
nitrat, NO3	**10.8**	mg/L	± 1.61	0.50	DV-5/ST	2023-03-24	W-ANI-SCR	PR	----	20	Tjänligt	
fluorid	**0.41**	mg/L	± 0.06	0.20	DV-5/ST	2023-03-24	W-ANI-SCR	PR	----	1.3	Tjänligt	
klorid	**229**	mg/L	± 34.4	0.50	DV-5/ST	2023-03-24	W-ANI-SCR	PR	----	300	Tjänligt med teknisk anmärkning	

Parameter	Resultat	*Enhet*	MU	*LOR*	*Analyspaket*	*Analys påbörjad*	*Metod*	*Utf.*	*Låg gräns*	*Hög gräns*	*Gränsvärde uppfyllt?*
Oorganiska parametrar - Fortsatt											
sulfat, SO4	**91.0**	mg/L	± 13.6	0.50	DV-5/ST	2023-03-24	W-ANI-SCR	PR	----	100	Tjänligt
Fysikaliska parametrar											
turbiditet	**12.2**	FNU	± 2.86	0.20	DV-5/ST	2023-03-22	Turbiditet	ST	----	3	Tjänligt med anmärkning
konduktivitet	**124**	mS/m	± 8.8	1.0	DV-5/ST	2023-03-22	Konduktivitet	ST	----	----	-
pH	**7.4**	-	± 0.2	3.0	DV-5/ST	2023-03-22	pH	ST	6.49	10.5	Tjänligt
färg	**134**	mgPt/l	± 40.3	2.0	DV-5/ST	2023-03-24	W-COL-SPC	PR	----	30	Tjänligt med estetisk anmärkning
Rapport											
bedömning	**Ja**	-	----	-	DV-5/ST	2023-04-04	DV-BED	ST	----	----	-

Metodsammanfattningar

Analysmetoder	*Metod*
W-AES-1A	Analys av metaller i sötvatten med ICP-AES enligt SS-EN ISO 11885:2009 och US EPA Method 200.7:1994. Provet är surgjort med 1 ml HNO3 (suprapur) per 100 ml före analys.
W-HARDNESS*	Beräknad från magnesium och kalcium
W-SFMS-5A	Analys av metaller i sötvatten med ICP-SFMS enligt SS-EN ISO 17294-2:2016 och US EPA Method 200.8:1994. Provet är surgjort med 1 ml HNO3 (suprapur) per 100 ml före analys.
W-ANI-SCR	Bestämning av bromid, fluorid, klorid, nitrit, nitrat samt sulfat med jonkromatografi enligt metod baserad på CSN EN ISO 10304-1. Filtrering av grumliga prover ingår i metoden.
W-CODMN-SPC	Bestämning av kemisk syreförebrukning, CODMn enligt metod baserad på CSN EN ISO 8467 Dekantering av grumliga prover ingår i metoden.
W-COL-SPC	Spektrofotometrisk bestämning av färg efter filtrering enligt metod CSN EN ISO 7887.
W-NH4-SPC	Spektrofotometrisk bestämning av ammonium, NH4, med låg LOQ enligt metod baserad på CSN EN ISO 11732, CSN EN ISO 13395, SM 4500-NO2, SM-4500-NO3. Filtrering av grumliga prover ingår i metoden.
W-PO4O-SPC	Spektrofotometrisk bestämning av fosfatfosfor enligt metod baserad på CSN EN ISO 6878 och SM 4500-P. Filtrering av grumliga prover ingår i metoden.
Alkalinitet	SS-EN ISO 9963-2, utg. 1 Provet titreras med saltsyra under avdrivande av koldioxid till slutpunkten pH 5.4.
DV-BED	Utgående dricksvatten samt dricksvatten hos användaren bedöms enligt LIVSFS 2022:12 - bilaga 1, reviderad januari 2023. Enskild brunn bedöms enligt Livsmedelsverkets riktvärden för små dricksvattenanläggningar för privat bruk, reviderad december 2022.
Konduktivitet	Bestämning av konduktivitet enligt SS-EN 27888, utg. 1. korrigerat till 25°C. Tidskänslig analys. Ackrediteringsområde 1-1000 mS/m.
Nitrit-N	Bestämning av nitrit/nitritkväve enligt SS-EN ISO 15923-1:2013, utg. 1 (diskret analys). Grumliga prover dekanteras alternativt filtreras.
pH	Bestämning av pH enligt SS-EN ISO 10523:2012, utg. 1. Tidskänslig analys. Ackrediteringsområde pH 3-11.
Turbiditet	Bestämning av Turbiditet enligt SS EN ISO 7027-1:2016 utg. 1.

Nyckel: **LOR** = Den rapporteringsgräns (LOR) som anges är standard för respektive parameter i metoden. Rapporteringsgränsen kan påverkas vid t.ex. spädning p.g.a. matrisstörningar, begränsad provmängd eller låg torrsubstanshalt.

MU = Mätosäkerhet

***** = Asterisk efter resultatet visar på ej ackrediterat test, gäller både egna lab och underleverantör

Mätosäkerhet:

Mätosäkerheten anges som en utvidgad osäkerhet (enligt definitionen i "Evaluation of measurement data- Guide to the expression of uncertainty in measurement", JCGM 100:2008 Corrected version 2010) beräknad med täckningsfaktor lika med 2 vilket ger en konfidensnivå på ungefär 95%.
Mätosäkerhet anges endast för detekterade ämnen med halter över rapporteringsgränsen.

Mätosäkerhet från underleverantör anges oftast som en utvidgad osäkerhet beräknad med täckningsfaktor 2. För ytterligare information kontakta laboratoriet.

Utförande laboratorium (teknisk enhet inom ALS Scandinavia eller anlitat laboratorium (underleverantör)).

	Utf.
LE	*Analys utförd av* ALS Scandinavia AB, Aurorum 10 Luleå Sverige 977 75 Ackrediterad av: SWEDAC Ackrediteringsnummer: 2030, ISO/IEC 17025
PR	*Analys utförd av* ALS Czech Republic s.r.o Prag, Na Harfe 336/9 Prag Tjeckien 190 00 Ackrediterad av: CAI Ackrediteringsnummer: 1163, CSN EN ISO/IEC 17025:2018
ST	*Analys utförd av* ALS Scandinavia AB, Rinkebyvägen 19C Danderyd Sverige 182 36 Ackrediterad av: SWEDAC Ackrediteringsnummer: 2030, ISO/IEC 17025

Analysrapport

ProvId: **73877** (RÅ-230321-1)

Provtaget: 2023-03-20 10:40 -°C
Mottaget: 2023-03-21 09:06 -°C
Provplats: Nedst-Svartjö_EYV2308
Kommun: Ekerö
Provtagare: Elsa
Provtyp: Ytvatten

Kund: Norrvatten
Kvalitet och Utveckling
Box 2094
169 02 SOLNA

Kemiska Analyser

Analyserna påbörjades: 2023-03-22

Analys	Resultat	Enhet	Mätosäkerhet (±)	Metod
TOC	17	mg/l	15 %	SS-EN 1484, utg 1

Inget utlåtande ges

Analysrapporten är digitalt signerad

Kemi: Anna Forsberg

Kopiemottagare

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Analysrapport

ProvId: **73878** (RÅ-230321-2)

Provtaget: 2023-03-20 14:07 -°C
Mottaget: 2023-03-21 09:08 -°C
Provplats: Ned_Skå-_EYV2302
Kommun: Ekerö
Provtagare: Elsa
Provtyp: Ytvatten

Kund: Norrvatten
Kvalitet och Utveckling
Box 2094
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Kemiska Analyser

Analyserna påbörjades: 2023-03-22

Analys	Resultat	Enhet	Mätosäkerhet (±)	Metod
TOC	4,4	mg/l	15 %	SS-EN 1484, utg 1

Inget utlåtande ges

Analysrapporten är digitalt signerad

Kemi: Anna Forsberg

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Analysrapport

ProvId:	**73879** (RÅ-230321-3)
Provtaget:	2023-03-20 14:58 -°C
Mottaget:	2023-03-21 09:09 -°C
Provplats:	Uppst_Skå-_EYV2301
Kommun:	Ekerö
Provtagare:	Elsa
Provtyp:	Ytvatten

Kund: Norrvatten
Kvalitet och Utveckling
Box 2094
169 02 SOLNA

Kemiska Analyser

Analyserna påbörjades: 2023-03-22

Analys	Resultat	Enhet	Mätosäkerhet (±)	Metod
TOC	3,4	mg/l	15 %	SS-EN 1484, utg 1

Inget utlåtande ges

Analysrapporten är digitalt signerad

Kemi: Anna Forsberg

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Analysrapport

ProvId:	**73899** (RÅ-230321-4)
Provtaget:	2023-03-21 11:00 -°C
Mottaget:	2023-03-21 15:46 -°C
Provplats:	Nedst_Johanneslund_SYV2305
Kommun:	Stockholm
Provtagare:	Elsa
Provtyp:	Ytvatten

Kund: Norrvatten
Kvalitet och Utveckling
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Kemiska Analyser

Analyserna påbörjades: 2023-03-22

Analys	Resultat	Enhet	Mätosäkerhet (±)	Metod
TOC	7,0	mg/l	15 %	SS-EN 1484, utg 1

Inget utlåtande ges

Analysrapporten är digitalt signerad

Kemi: Anna Forsberg

Kopiemottagare

Analysrapport

ProvId:	**73900** (RÅ-230321-5)			
Provtaget:	2023-03-21 12:49	-°C	Kund:	Norrvatten
Mottaget:	2023-03-21 15:47	-°C		Kvalitet och Utveckling
Provplats:	Uppst_Johanneslund			Box 2094
Kommun:	Stockholm			169 02 SOLNA
Provtagare:	Elsa			
Provtyp:	Ytvatten			

Kemiska Analyser

Analyserna påbörjades: 2023-03-22

Analys	Resultat	Enhet	Mätosäkerhet (±)	Metod
TOC	25	mg/l	15 %	SS-EN 1484, utg 1

Inget utlåtande ges

Analysrapporten är digitalt signerad

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