DEPARTMENT OF BIOLOGICAL
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PFAS in Drinking Water: Institutional Responsibilities and Regulatory Gaps caused the Ronneby incident?

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Abstract

PFAS (per- and polyfluorinated alkyl substances) are a collective name for over 10,000 synthetic chemicals. They are characterized by their persistence, bioaccumulation, and high mobility in aquatic environments, and their hydrophobic and lipophobic properties make them useful in firefighting foam. On December 16, 2013, extremely high levels of PFAS were found in the drinking water from the Brantafors waterworks. The source could be traced back to a fire training site at Blekinge air base (F17), where the Swedish Armed Forces had used firefighting foam containing PFAS since the 1980s. The study shows that international knowledge of PFAS risks existed long before 2013. Even early indications of similar contamination cases in Sweden, such as in Tullinge (2011) and Halmstad (2009), did not lead to coordinated national measures or changed guidelines. The Ronneby case identifies several actors who had the opportunity and, in some cases, the obligation to act preventively, but where lack of communication, insufficient regulatory compliance, or limited mandates contributed to passivity. These actors include manufacturers (who knew the risks but withheld information), the Swedish Armed Forces (which failed to conduct self-control and risk assessment despite internal knowledge), Ronneby Miljö & Teknik AB (which was responsible for the drinking water supply but relied on limited government directives), and national authorities such as the Swedish Chemicals Agency, the Swedish Environmental Protection Agency and the Swedish Food Agency, whose knowledge was not effectively communicated to the municipal level.

The precautionary principle and Ch 26 § 19 in the Swedish environmental code were not followed through, and the fragmented chemicals regulation under the REACH Regulation has proven insufficient, mainly since PFAS regulation was carried out on a substance-by-substance basis for a long time. The late introduction of limit values for PFAS in the EU Drinking Water Directive also contributed to delayed action.

The PFAS contamination in Ronneby illustrates a systematic failure characterized by unclear mandates, fragmented responsibilities, poor communication, and regulatory weaknesses. Actors who acted independently of each other, and several warning signs were ignored. The Ronneby case is, therefore, not an isolated exception but follows a recurring pattern from previous environmental toxics crises, such as with DDT and PCB, and underlines the need for better knowledge transfer between authorities and the local level, a more proactive risk assessment and better regulatory framework for the management of persistent chemicals.

Sammanfattning

PFAS (per- och polyfluorerade alkylämnen) är ett samlingsnamn för över 10 000 syntetiska kemikalier. De kännetecknas av sin uthållighet, bioackumulering och höga rörlighet i vattenmiljöer, och deras hydrofoba och lipofoba egenskaper gör dem användbara i brandbekämpningsskum. Den 16 december 2013 hittades extremt höga halter av PFAS i dricksvattnet från Brantafors vattenverk. Källan kunde spåras tillbaka till en brandövningsplats vid Blekinge flygbas (F17), där Försvarsmakten hade använt släckskum innehållande PFAS sedan 1980-talet.

Studien visar att internationell kunskap om PFAS-risker fanns långt före 2013. Inte ens tidiga indikationer på liknande föroreningsfall i Sverige, som i Tullinge (2011) och Halmstad (2009), ledde inte till samordnade nationella åtgärder eller ändrade riktlinjer. Ronnebyfallet identifierar flera aktörer som haft möjlighet och i vissa fall skyldighet att agera förebyggande men där bristande kommunikation, otillräcklig regelefterlevnad eller begränsade mandat bidrog till passivitet. Dessa aktörer är bland annat tillverkare (som kände till riskerna men undanhöll information), Försvarsmakten (som trots intern kunskap misslyckats med egenkontroll och riskbedömning), Ronneby Miljö & Teknik AB (som ansvarade för dricksvattenförsörjningen men förlitade sig på begränsade myndighetsdirektiv), och nationella myndigheter som Kemikalieinspektionen, Naturvårdsverket och Livsmedelsverket vars kunskaper inte blev kommunicerade vidare till kommunen.

Försiktighetsprincipen och 26 kap § 19 i den svenska miljöbalken efterlevdes inte, och REACH-förordningen har visat sig vara otillräcklig, främst då PFAS-reglering har genomförts ämne för ämne under lång tid. Det sena införandet av gränsvärden för PFAS i EU:s dricksvattendirektiv bidrog också till försenade åtgärder.

PFAS-föroreningen i Ronneby illustrerar ett systematiskt misslyckande som kännetecknas av oklara mandat, fragmenterat ansvar, dålig kommunikation och brister i regelverket. Aktörer som agerade oberoende av varandra, och flera varningssignaler som förbisågs. Ronnebyfallet är därför inte ett isolerat undantag utan följer ett återkommande mönster från tidigare miljögiftskriser, som med DDT och PCB, och understryker behovet av bättre kunskapsöverföring mellan myndigheter och lokal nivå, en mer proaktiv riskbedömning och bättre regelverk för hantering av långlivade kemikalier.

Popular science summary

PFAS is a collective name for over 10,000 chemicals, and they are manmade, very stable substances called “forever chemicals” because they do not break down naturally in nature. Their properties make them useful in applications such as firefighting foam. In December 2013, very high levels of PFAS were discovered in the Brantafors waterworks in Ronneby. Approximately 5,000 people had received contaminated drinking water. The contamination was traced to the F17 air fleet, where the Swedish Armed Forces had been using PFAS-based firefighting foam since the 1980s. Despite international knowledge of the risks existing long before 2013, PFAS was missing from the Swedish Food Agency analysis list, and there were no specific requirements in Swedish drinking water legislation. At the same time, the Environmental Code could have been used to prevent or limit pollution, but several actors failed in their supervision and responsibility. This study analyses why no one acted on time despite several actors having both knowledge and responsibilities. The method consists of a qualitative case study with document analysis, interviews, and international comparisons. The analysis focuses on four themes: responsibility, communication, knowledge, and action.
The results show that Ronneby was not an exception but an example of a recurring pattern where responsibility is fragmented, regulations are inadequate, and authorities fail to act preventively. Ronneby illustrates a global problem where society often reacts only after the damage has already been done.

Acknowledgement

I am incredibly grateful to my supervisor, Dan Strömberg, for his direction, assistance, and support during this project. His encouragement has been helpful in times of doubt, and his feedback has helped me improve the quality of my thesis. I would also like to thank the County Administrative Board of Blekinge, the Swedish Armed Forces, the Swedish Chemical Agency, the Swedish Food Agency, and the European Chemical Agency for their participation in answering my questions.

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1. Introduction

1.1 Background information: Contaminated drinking water in Ronneby municipal

Sustainable access to safe drinking water is acknowledged as an essential human right and is established as Goal 6 of the Sustainable Development Goals (SDGs). It is essential to minimize water pollution, as anthropogenic chemicals in drinking water pose risks to human health (Sadia et al., 2023). PFAS, highly fluorinated substances, have become an increasing environmental and public health concern. According to the Swedish Society for Nature Conservations (Naturvårdsverket) 2024 analysis report, PFAS were found in all sampled streams, lakes, and rainwater and in 9 out of 10 drinking water samples, regardless of whether the source was municipal systems, private wells, or shared community supplies. In one out of ten cases, PFAS levels exceeded the upcoming regulatory limit for drinking water. The most frequently detected compound was TFA, which was also measured in the highest concentrations (Naturskyddsföreningen, 2024).

On December 16, 2013, it was discovered by the County Administrative Board of Blekinge and Ronneby Miljö & Teknik AB that the drinking water from the Brantafors waterworks contained very high levels of PFAS (perfluoroalkyl and polyfluoroalkyl substances)(Ronneby kommun, 2024b). PFAS was not previously included in the list of substances recommended for analysis according to the guidelines set by the Swedish Food Agency. Its discovery resulted from the County Administrative Board's expanded environmental monitoring in the autumn of 2013. Approximately 5000 residents were supplied the contaminated water from the Brantafors water treatment plant (Ronneby Kommun, 2024a).

Within weeks of the contamination being discovered, a comprehensive study program was launched to examine the health implications of PFAS exposure. Even though the contaminated water supply was shut down and the water was replaced with clean water, investigations revealed that consumers who had previously consumed the contaminated water still had elevated PFAS levels. It was also shown in the studies that women with high PFAS levels can transfer them to their children during pregnancy and while breastfeeding. The research confirmed that PFAS exposure is linked to higher cholesterol levels and increased risk of kidney cancer, supporting a causal relationship (Jakobsson, 2023).

The pollution originated from a fire training site at the Blekinge Air Fleet, where the Swedish Armed Forces had been using firefighting foam containing PFAS to put out oil and gasoline fires since the mid-1980s. Undetected, the contamination spread from the training site to the groundwater and eventually to the drinking water ("T 486-23,," 2023). The extinguishing exercises have mainly been carried out on a concrete surface, from which the extinguishing water runs off onto the surrounding ground to be collected in an open pond on the eastern side of the training area. In the mid-1990s, the fire training area was rebuilt. The pond was filled with excavated material from the former training area, and a system for diverting extinguishing water to the wastewater network was installed (Försvarsmakten & Miljöprövningsenheten, 2016).

Although PFAS were not previously included in the Swedish Food Agency's recommended analysis parameters, extensive international knowledge about the risks of the substance group existed long before 2013. Companies such as 3M and DuPont knew about the toxicity and persistence of PFAS substances for decades, but the information was withheld from the public (3M, 1978; Carrington, 2025; Hayes & Faber, 2020). The first time PFAS was found in drinking water was in 1984 (USA) (Rosengren et al., 2024). PFAS are persistent, bioaccumulative, and easily transported in water, making them particularly problematic in connection with drinking water supplies (Cousins et al., 2020; Sadia et al., 2023). In Sweden, there were already indications of PFAS contamination before the Ronneby incident, including at F14 in Halmstad in 2009 and Tullinge in 2011, where high levels of PFAS were measured in the groundwater (Naturskyddsföreningen, 2022). Despite these signals, no comprehensive national regulatory framework was launched, and the responsible authorities had limited mandates or lacked coordination.

The case in Ronneby stands out as one of Sweden's most extensive PFAS contamination cases, both in terms of concentrations and number of affected residents. It has also gained great legal significance when the Armed Forces were sued for environmental damage ("T 486-23,," 2023). The study in Ronneby thus serves as a critical case study to understand why actors did not act in time, how the division of responsibility broke down, and which system failures allowed for long-term exposure.

1.2 PFAS: A chemical with risk

1.2.1 Definition and Properties of PFAS

PFAS (per- and polyfluorinated alkyl substances) are a broad and complex category containing over 10,000 identified substances (Naturvårdsverket, 2024a). They are industrially produced chemicals that contain strong carbon-fluorine bonds, one of the most stable chemical bonds. This stability hampers the degradation of PFAS in the environment as well as in humans. They are often referred to as “forever chemicals” because of their longevity. PFAS are water, grease, and dirt repellent, which has made them useful in various products such as textiles, food packaging, cosmetics, firefighting foam, and non-stick coatings (European Chemicals Agency, 2025a; Kemikalieinspektionen, 2025b).

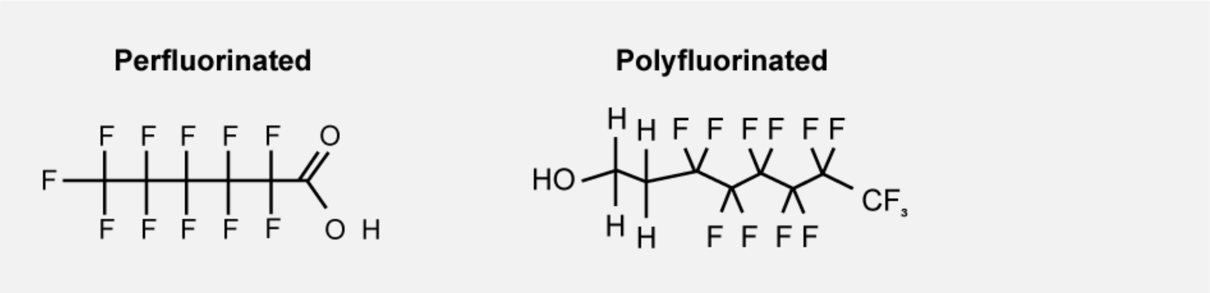

Figure 0-1: Perfluorinated is a fully fluorinated carbon chain and polyfluorinated is a partially fluorinated carbon chain (Kemikalieinspektionen, 2025b)

Most substances consist of a hydrophilic e.g. (COOH) and hydrophobic part (C-F). PFAS are divided into long-chain and short-chain substances depending on the number of carbons in the fluorinated chain. PFOS (Perfluorooctanesulfonate) and PFOA (Perfluorooctanoic acid), which were commonly used in fire foams in the past, have eight carbons, and PFHxA (Perfluorohexanoicacid) and PFHxS (Perfluorohexanesulfonic acid) have 6 carbons. The long-chain ones were long considered to be much more dangerous than the short-chain ones, but it has been shown that they are just as dangerous (Kemikalieinspektionen, 2025b; Rosengren et al., 2024).

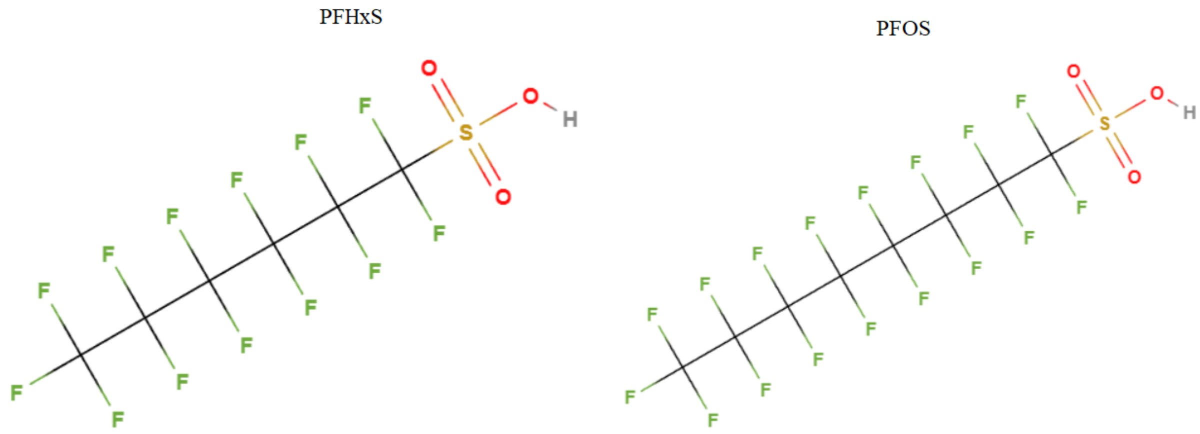

Figure 2: Made in molview.org 2025-05-07. Illustrates the similarities between the different substrates with PFOS only two carbon fluor groups separating them.

Environmentally, PFAS are highly problematic because they can be dispersed over long distances in water and stored in soil and sediment. They do not degrade naturally in the environment and can therefore contaminate groundwater for decades after release, making remediation both technically difficult and economically costly (European Environment Agency, 2025).

1.2.2 PFAS: in firefighting foam

One of the most significant uses of PFAS has been in so-called AFFF (Aqueous Film Forming Foam), especially at military training grounds and airports. These foams contained PFOS, PFOA, and other long-chain PFAS that are both bioaccumulative and persistent (Hayes & Faber, 2020). Firefighting foam containing PFAS is also the largest known point source of PFAS to the environment. Just a few liters of firefighting foam can contaminate the drinking water of a small town (Naturvårdsverket, 2024c). 3M knew its firefighting foam contained toxic chemicals yet told its customers it was harmless and biodegradable. However, documents reveal evidence showing PFOS is not biodegradable as early as 1949 (The Guardian, 2025). In early 2000, 3M announced they would remove PFOS from all products, and the “phasing out” of PFOS begun, although the phase-out was deliberately postponed until the existing inventory had been exhausted, and then only to be substituted with equally harmful PFHxS (Rosengren et al., 2024). In Ronneby, PFAS-based foam was used for several decades at the Blekinge Air Force Base, which ended up in extensive groundwater contamination ("T 486-23,," 2023). The firefighting foam was often flushed into the ground or sewage system without collection, and there was a lack of control or after-treatment. This led to thousands of residents of Ronneby being exposed to PFAS through their drinking water (Kaliber P1, 2019).

1.2.3 Health risks and environmental impact

PFAS substances are both hydrophobic and lipophobic, and they can bind to proteins in the blood, causing them to accumulate in the body over time. Structurally, acidic PFAS compounds have a terminal acid group and a long, highly hydrophobic carbon chain. Because they resemble fatty acids, they can compete with them for binding to various transport proteins in the body (Zhao et al., 2023). The study by Nordby & Luck (1956) shows how PFOA, a type of PFAS, binds strongly to the blood protein albumin, contributing to the substance's long-term presence in the body and affecting its transport and potential toxicity. (Nordby & Luck, 1956). They are linked to a range of health problems such as elevated cholesterol levels, impaired immune function, liver damage, hormonal disorders, effects on fertility, and certain forms of cancer, including kidney and testicular cancer (EPA, 2024; Jakobsson, 2023).

All PFAS have in common their ability to spread over long distances through air and water. PFAS can, therefore, be detected in areas where no production or use has occurred, such as in Arctic environments, and PFAS have been found even in Polar bears (Smithwick et al., 2005) (Kemikalieinspektionen, 2025b).

Some PFAS compounds can bioaccumulate in living organisms and can be biomagnified through food chains. In fish, a clear correlation has been observed between the degree of accumulation and the length of the PFAS molecule's carbon chain. Long-chain PFAS tend to accumulate more readily, whereas short-chain variants are more easily excreted. In contrast, plant uptake follows an inverse pattern; studies show that short-chain PFAS are absorbed more efficiently than their long-chain counterparts, indicating that uptake mechanisms differ between organism types and trophic levels (Kemikalieinspektionen, 2025b).

1.3 Aims and Research Questions

PFAS, or "Per- and polyfluoroalkylated substances," are synthetic chemicals widely used in firefighting foam, contributing to the contamination of drinking water.
The event in Ronneby serves as a basis for conducting a thorough review of mapping the roles of various actors, highlighting their responsibilities in managing PFAS. The aim is to demonstrate the importance of learning from mistakes and understanding the reasons behind actions and inactions to prevent similar issues in the future.

- Citizens expect that actors and authorities protect them against serious health issues, particularly concerning critical events such as contaminated drinking water. Why did this fail in the Ronneby incident?
- Who could have intervened? Who should have intervened? Why is it difficult? Which actors are involved?
- Have there been similar incidents in other countries?
- Can it happen again?

2. Method

This master's thesis applies a qualitative case study design, intending to deepen the understanding of institutional responsibility, regulatory shortcomings, and government communication concerning PFAS contamination in the municipality of Ronneby. The study is based on a multi-case design where Ronneby is the primary analysis example, supplemented with international comparisons and historical parallels to identify patterns in managing persistent chemicals.

2.1 Research strategy and design

The study is based on a qualitative actor analysis as a methodological framework. Different institutional actors, such as state authorities, municipal bodies, and military operations, are analyzed concerning their roles, division of responsibilities, and actions during different stages of the sequence of events. A critical institutional perspective is used to understand why no actor took responsibility in time and what systemic failures allowed the contamination to continue.

2.2 Data collection

Data collection has been carried out through four primary methods:

- Document analysis of public reports, government documents, court cases (e.g., Case no. 1280–21), scientific articles, and municipal information published on the Ronneby municipality website.
- Semi-structured interviews with representatives from the Armed Forces, the County Administrative Board of Blekinge, the Swedish Chemical Agency, the Swedish Food Agency, and the European Chemicals Agency (ECHA). These were selected based on their central roles in environmental supervision, chemical control, and drinking water regulation.
- Comparative case studies from Peterson Air Force Base in USA and at Oakey Army Aviation Centre, Australia are used as a reference frame to identify alternative ways to deal with similar PFAS contamination.
- A timeline analysis has been carried out to create a chronological understanding of the rise of PFAS, how the events in Ronneby developed, which incidents were critical for information transfer, and different milestones that marked changes in the process.

2.3 Analysis method

The material has been analyzed through thematic analysis (Braun & Clarke, 2006) where central themes have been coded based on questions about responsibility, action, communication, knowledge level, and reaction ability. The analysis is structured based on three temporal phases:

1. Before the discovery (pre-2013): Focus on risk awareness, regulations, supervision, and communication.
2. At the discovery (2013–2014): How the actors acted, what measures were taken, and how communication worked.
3. After the discovery: Policy changes, working methods, lessons learned, and new routines or regulations.

2.4 Selection and limitations

The interview actors were selected based on their formal or practical responsibilities in chemical regulation, water management, and environmental protection. Interviews have been conducted with the Swedish Armed Forces, Blekinge County Administrative Board, the Swedish Chemicals Agency, the Swedish Food Agency, and ECHA/REACH, representing a broad spectrum of perspectives.

Several limitations have affected the data collection, however:

- Ronneby Municipality was contacted, but since none of those directly involved in the 2013 incident were still in service, the municipality could not provide interview material. Instead, they referred to public information on the municipality’s website. Ongoing legal proceedings also led to a certain restraint in communication.
- The Swedish Environmental Protection Agency was contacted on repeated occasions but did not respond within the time frame for the study, probably due to a lack of time.

- Swedish Water and the Swedish Marine and Water Management Agency (HaV) declined to participate, citing that the questions were not considered within their areas of relevance.

The fact that the municipal perspective could not be included through interviews has been largely compensated for by extensive and insightful material from the Blekinge County Administrative Board, which had a coordinating and supporting role during the event. The County Administrative Board's contribution has provided good insight into the local process and the municipality's actions from an overall authority perspective.

3. Results

3.1 Which actors could have played a role in preventing/mitigating the contamination in Ronneby?

This chapter will provide an overview of which actors had the opportunity to prevent or mitigate the contamination in Ronneby. The actors are reviewed based on possible preventive measures and challenges, with a brief reflection on their role. Table 1 summarizes the aspects and serves as a foundation for further analysis of the actor's responsibilities and actions.

Tabell 1: Overview of key actors, their potential preventive measures, challenges faced, and reflections on their role in the PFAS contamination case in Kallinge.

Actor	**Potential measures**	**Constraints and barriers**	**Reflection**	**Reference**
The manufacturers/importers of firefighting foam (AFFF)	Could and should have reported the environmental and health risks of PFAS in safety data sheets and discontinued sales once credible evidence of harm emerged.	Financial motivation: Profitable and effective. Admitting to environmental or health risks could affect sales. Limited legal obligation: Environmental regulations did not require full disclosure of long-time risks or delayed health effects. SDS focused on immediate hazards	Documents showed that manufacturers like 3M knew of PFAS toxicity but continued to distribution.	(3M, 1978; Blum et al., 2015)
REACH (Registration, Evaluation, Authorization and Restriction of Chemicals)	A more comprehensive investigation by the manufacturer/importer should have been required under REACH, and authorization should have been denied.	Substance-by-substance regulation: REACH initially assessed individual substances rather than grouping them. This approach delayed comprehensive risk assessments for PFAS as a chemical class. Persistence and known risks: Despite the well-documented persistence of PFAS in the environment, there was no regulation of these substances until much later.	Despite known persistence, REACH failed to regulate PFAS until long after risks were known.	(Cousins et al., 2020) (Bock & Laird, 2022; European Chemicals Agency, 2024b)

The Swedish Armed Forces	Failure to apply Chapter 26§19 of the Environmental Code: States that those responsible for a business or activity that could potentially harm human health, or the environment must proactively manage and monitor their operations to avoid or reduce any negative consequences. A more thorough risk assessment about spreading chemicals should have been done to minimize leakage.	Relied on outdated safety data, no knowledge of PFAS.	As primary polluter, responsibility to assess and prevent environmental damage was neglected.	(Försvarsmakten & Miljöprövningsenheten, 2016; SFS 1998:808, 1998)
The Environmental municipality in Kallinge	Chapter 7§21 TEC: Governs water protection areas. The guiding principle emphasizes that land and water areas must be protected to ensure water resources, which require that regulations be developed based on the specific conditions and risks present in the area, have been overlooked. Regularly investigated contamination risks.	Limited resources and no PFAS-specific guidelines.	Water sources near airports should receive stricter risk assessments. Environmental scanning and communication and cooperation between authorities was lacking.	(Ronneby kommun, 2025; SFS 1998:808, 1998)
Ronneby Miljö & Teknik AB	Should have conducted broader water quality testing beyond the official checklist and more aware of the surrounding activities considering it is a water protection area.	Depended on Swedish Food Agency's guidelines; PFAS not included before 2013.	Failed to make proper risk assessment. Highlights the risk of relying solely on regulatory lists.	(Ronneby kommun, 2024b)
Swedish Agency for Marine and Water Management	Could have retrieved information about PFAS cases in other countries, analyzed how Sweden was doing comparatively, giving warning about potential risks. Should have investigated the Swedish situation and identified threatened areas.	Limited mandate at the time, PFAS not a priority, lack of national strategy for water pollution, new agency (2011).	A key actor in water management. Should have played a more proactive role in identifying risks in sensitive water areas.	(Naturskyddsföreningen, 2022)
The Swedish Chemical Agency	Could have retrieved	The complexity and size of the PFAS group made	The agency had early knowledge of PFAS risks but	(Kemikalieinspektionen, 2023a)

	information about similar PFAS cases in other countries, analyzed risks, and proposed national measures, such as previous mapping and classification of PFAS substances.	regulation difficult. Limited resources and slow EU regulatory processes.	moved slowly due to bureaucratic hurdles. It could have had a more significant impact on national chemical policy.	
The Swedish Environmental Protection Agency	Could have compiled knowledge about PFAS from international sources and Swedish data and disseminated information to municipalities and other authorities. Should have analyzed national risks earlier.	Initial focus on surface water; no routine PFAS tracking.	Missed signals from other countries and cities in Sweden e.g., F14 in Halmstad and early research. Could have played a key role in connecting environmental protection and chemical regulation—became active only after the Ronneby incident.	(European Environment Agency, 2025; Kaliber P1, 2019; Naturskyddsföreningen, 2022)
Swedish Food Agency	If the Swedish Food Agency had systematically reviewed evidence of PFAS contamination in other countries such as the USA, it could have initiated precautionary actions earlier by introducing limit values or initiating a discussion in Sweden about the risks of PFAS in drinking water.	PFAS were not included in the guidelines at the time. Limited international coordination before 2013.	Important actor after 2013. Could have been more proactive before 2013. The lack of limit values hampered the implementation of local initiatives.	(Jakobsson, 2023; Kaliber P1, 2019; Livsmedelsverket, 2014b)

3.2 Synthesis of Actors interview

The following section presents interview-based insights from key actors involved in the PFAS contamination case in Kallinge. Actors available for answering questions were the Swedish Armed Forces, The county administration board, ECHA, the Swedish chemical agency, and the Swedish food agency. While efforts were made to include a broad range of perspectives, it is important to note that Ronneby Municipality could not participate. Individuals directly involved at the time are no longer employed, and current staff declined to comment on events they were not involved in, particularly due to ongoing legal proceedings. Although the County Administration Board did fill some of that gap. Similarly, individuals formerly responsible at the municipal water company were unavailable. The Swedish Environmental Protection Agency was also contacted, but no response was received within the period of this study.

3.2.1 The Swedish Armed forces

State of knowledge prior to Brantafors and Ronneby (Pre-2013)

The Swedish Armed Forces claimed that their knowledge of PFAS was limited before 2013. They stated that there was a widespread perception that chemical legislation provided sufficient protection and that approved products did not pose significant environmental risks. According to the Swedish Armed Forces, their safety data sheets lacked information about PFAS as persistent substances. They further asserted that in the 1980s, instructions were that firefighting foam could be flushed down the drain.

They further explained that internal documentation from manufacturers such as 3M and DuPont showed that the risks of PFAS were known as early as the 1960s, but the information was withheld. PFAS compounds such as PFOS and PFOA began to be banned in the EU in 2006 (Swedish law 2008), and that they then replaced foam with short-chain PFAS products, which, unfortunately also turned out to break down into persistent substances.

They emphasize that there were no requirements for measuring PFAS in the environment before 2013, stating that guidelines for handling firefighting foam during exercises were unclear.

Reactions following the discovery in Ronneby in 2013

The Swedish Armed Forces reported that immediate actions were taken when PFAS contamination was discovered in the drinking water in Ronneby 2013. They stated that they stopped using PFAS-based foam in the area, the training site was closed in accordance with a garrison order and they sealed the wastewater pipeline.

They claim that a series of environmental engineering investigations began in 2014, including dispersion analyses, sampling of groundwater and stormwater, and testing various remediation options. They reported that many source areas (35+) in Sweden had been identified, and three are currently being investigated for immediate remediation measures.

According to their own statement, knowledge about risks, spread, and technical solutions for clean-up was initially low. Until 2016, they argued that they were missing clear action limits. The Swedish Armed Forces claims that they had followed regulatory requirements, taken protective measures such as new water pipes, and carried out investigations in accordance with the rules of the Environmental Code.

Guidelines, monitoring, and government oversight

They stated that before 2013, some guidelines regarding handling foam and waste existed, but they were unclear and varied in interpretation. They argued that safety data sheets did not provide enough guidance. The guidelines were not consistently followed, resulting in PFAS in the environment.

They acknowledged that there was no systematic measurement or monitoring of PFAS content. They further informed that monitoring programs were introduced only after the Ronneby incident and that sampling and controls are ongoing today at fire training sites.

From their point of view, regulatory oversight prior to 2013 was insufficient and fragmented. They informed that existing chemical legislation was sufficient. After 2013, regulatory authority's requirements increased, and increased cooperation was initiated with, among others, the Swedish Environmental Protection Agency and municipal authorities.

Legal and technical challenges

The Swedish Armed Forces maintained that they have acted in accordance with the Environmental Code's requirements since the discovery of PFAS contamination. They stated that liability assessments under Chapter 10 of the Environmental Code must be made, considering the state of knowledge at the time of the releases.

They lastly pointed out that technology for remediation was previously limited and that research was required to understand the spread, half-life and purification methods. Purification techniques such as carbon filtration were developed after 2013, but they claimed that early trials with biochar showed limited effect. Today, response techniques are being tested on a full scale.

- Reflection, Commentary, and Summary of the Swedish Armed Forces interview

The Swedish Armed Forces' statements reflected limited knowledge, unclear regulatory guidance, and a reactive rather than a proactive risk management approach prior to 2013. Putting this in contrast to with the international awareness of the hazards coming with using PFAS, which had emerged much earlier, research has shown that manufacturers were conscious of the environmental and health risks concerning PFAS decades earlier (Faber & Hayes, 2020; The Guardian, 2025) and that in 2004 KemI suggested starting to phase out PFOS (European Parliament and Council, 2006a). Moreover, PFAS had already been detected at other military facilities, for instance in Halmstad (Naturskyddsföreningen, 2022), which suggest that internal knowledge about the environmental risks of firefighting foam actually did exist within the organization. Yet, no systematic mapping or risk assessment was conducted for other facilities, e.g., at their training site in Ronneby. This shows limitations within internal information management and suggests that the organization might not have fully met the obligations with the Environmental Code's requirements for self-inspection (Chapter 26, Paragraph 19) (SFS 1998:808, 1998). The interview also showed that technical knowledge about the spread and remediation of firefighting foam was insufficient, which might be understandable. However, it reinforces the importance of applying the precautionary principle when there are uncertainties. After 2013, a more responsible approach was initiated involving sampling, remediation work, investigations, and no PFAS-based firefighting foam in Ronneby, e.g., (Försvarsmakten & Miljöprövningsenheten, 2016).

3.2.2 The County Administration Board

The County Administrative Board claims that they had minimal knowledge of PFAS before the contamination in Brantafors waterworks was discovered in 2013. The substance group was not included in their regular environmental monitoring, which instead focused on other pollutants such as heavy metals, brominated flame retardants, and dioxins. Although they acknowledged it was known that PFAS was present in products such as firefighting foam and impregnation, they pointed out that they lacked understanding of how the substance could be transported in the environment and affect the drinking water. The County Administration Board explained that the discovery was made in connection with a broader sampling screening, and immediately they informed the municipality.

They also asserted that the municipality was formally responsible for ensuring that the drinking water was of good quality. But they also pointed out that the municipality had not received any guidance that PFAS could be a relevant risk to monitor. They explained that The National Food Agency had an advisory role and was responsible for guidelines but lacked specific requirements for PFAS control before 2013. The County Administrative Board acted mainly in a supportive manner towards the municipalities and focused its monitoring on other pollutants. The Swedish Chemicals Agency had some information about PFAS, but the communication did not reach the actors responsible for water quality. They went on saying that the Environmental Protection Agency did not have PFAS as a priority before 2013 and that The Swedish Armed Forces, had no strategy for following up or controlling the spread of the substance before it was detected in the drinking water.

After 2013, the County Administration board's stated that their role had changed from passive and reactive to a more active and coordinating one. They assisted the municipality in sampling and risk assessment and improved communication between authorities and told they began contributing to national and international policy discussions related to PFAS, initiated broader risk inventories, and supported the inclusion of PFAS in regional monitoring efforts.

They acknowledged that several shortcomings have been identified in hindsight. They emphasized that the municipalities lacked guidance, and responsibilities between actors were unclear. That those who needed information about PFAS did not get it. They stated that there was no effective mechanism for risk assessment of new substances, and the legislation did not include requirements to analyze PFAS in drinking water. Stating, it was both challenging and costly to remediate. Changing the water source and implementing effective purification methods took considerable time.

The County Administrative Board also claimed that there were situations where they felt they should have acted but did not. Giving the example, in not testing for PFAS in water despite the firefighting foam had been used in the area for a long time. They further explained that The Armed Forces' activities were not examined from that perspective, and there were no procedures for proposing new chemicals in the monitoring programs and that the information was available to certain authorities, but no one was responsible for ensuring it reached the municipalities.

The County Administration board points out that prior to 2013, risk assessments for the drinking water source in Kallinge focused on conventional environmental pollutants. The evaluations did not include Firefighting foam and PFAS because these substances were neither regulated nor recognized as risks. They point out that if an open-ended risk inventory had been made with more substances being analyzed and by reviewing what type of operations nearby they stated that might had led to identifying the contamination earlier. But according to them this was hindered by a lack of knowledge, unclear responsibilities, absence of legislation, and limited resources.

They highlighted that communication was a big issue, that existing information about PFAS did not reach municipalities or water utilities. Authorities operated in parallel systems without coordination, and there was no effective warning mechanism. Since 2013, they argue, things have improved through new working groups and clearer divisions of responsibility.

Recommendations given by the County Administrative Board to prevent similar issues in the future were to improve communication and cooperation between authorities, stricter legislation and testing requirements, regular risk assessments, clear accountability for remediation, advancements in purification technology, and enhanced competence in addressing chemical and environmental risks.

- Reflection, Commentary, and Summary of the County Administration Board interview

The County Administrative Board stated they had limited knowledge about PFAS before 2013, although it was known to them that PFAS was present in firefighting foam, it was not included in environmental monitoring. They stated that there was a lack of guidance and requirements from national authorities, which meant PFAS was not recognized as a relevant environmental risk at the regional level.
They pointed out that the municipality was responsible for drinking water quality, but they had not received any guidance on PFAS from national agencies. At the same time, there were not any effective mechanisms for communicating upcoming environmental risks between authorities yet, which meant important information did not reach responsible actors. There is an element of self-criticism in the interview, where the County Administrative Board states that they should have realized and acted, that there was a risk with a fire-training site near the water source, which you would think should have raised awareness by any of the actors mentioned in this study, however but due to insufficient knowledge, unclear mandates, and a lack of support from national guidelines that didn’t happen. They had a more active role after 2013, supporting municipalities with sampling and risk assessment, and participated in the improved coordination between agencies regarding PFAS (Kemikalieinspektionen, 2023b). In hindsight, greater political attention and investment should and needs to be directed towards environmental issues.

3.2.3 REACH

According to the European Chemical Agency (ECHA), REACH (Registration Evaluation Authorization and Restriction of Chemical) plays a preventive role by regulating substances that are threatening human health and the environment. They acknowledge that REACH was not particularly designed as a reactive instrument for local pollution incidents it is rather intended to identify hazardous substances, communicate risks through the supply chain, and implement restrictive measures where needed.

ECHA states that since the incident in Ronneby in 2013, development regarding restrictions on PFAS in firefighting foams has been proposed under REACH. They describe that these restrictions’ purpose is to eliminate the use of PFAS in firefighting applications gradually. They inform that this reaction of REACH can be seen as the reaction towards past incidents aiming to prevent similar occurrences in the future.

They also pointed out that had risks been adequately understood and assessed earlier, stricter actions could have been introduced sooner. They also informed that PFAS substances had been used for decades before REACH was established in 2007. They further informed that PFAS substances were widely used before complete hazard and exposure data were available or required under REACH. ECHA says that the system has since enabled a more proactive approach, and regulatory tools continue to develop.

They maintain that Safety data sheets (SDS) may not always provide a comprehensive picture of the risks, particularly for long-term or indirect effects, and that not all endpoints, such as carcinogenicity resulting from degradation products, are always included. They go on to say that primarily, when data gaps exist, or the information is not required under current regulatory thresholds. ECHA explains that the different degradation paths of PFAS can be complex, leading to harmful transformation products or other persistent substances, and points out that while the understanding of these pathways continues to improve, some uncertainty remains, making it challenging to determine specific endpoints for PFAS. They state that, while it may not be accurate to label this as "misleading," it is clear that some SDSs might not entirely reflect the complexity of PFAS-related risks.

They emphasize that the REACH framework is continuously evolving to meet scientific and societal demands. They explain that some positive steps include the adoption of grouping strategies and faster risk management measures, and regarding firefighting foams, the ECHA Committee has evaluated a PFAS restriction proposal. ECHA highlights the development of broader efforts, such as the Universal PFAS Restriction Proposal, to proactively ensure that regulation keeps pace with scientific progress and emerging chemical risk knowledge.

➢ Reflection, Commentary, and Summary of REACH interview

ECHA asserts that REACH was not intended to address local PFAS contamination, but rather it is designed to focus on a specific application, such as firefighting foams. The authorization is given for a specific application. However, they do play a preventive role by regulating substances that pose risks to human health and the environment. They acknowledged that REACH was not designed to handle PFAS as a group of substances but instead focused on individual chemicals. This has, in hindsight, been proven to be insufficient, considering the PFAS group consists of thousands of persistent substances with similar properties (Cousins et al., 2020). The fact that REACH was not implemented until 2007, and many different PFAS substances had been used for a long time before comprehensive hazard assessments and reliable data on human and environmental exposure levels were available or were mandatory under REACH. This demonstrates how slow regulation contributed to harmful chemicals spreading for a long period without being detected, leaving communities with unsafe drinking water. In 2004, Sweden proposed to include PFOS in the Stockholm Convention (Kemikalieinspektionen, 2025c), this shows that, prior to the implementation of REACH, the management of PFAS within the EU was characterized by inadequate coordination and limited effectiveness.

Since REACH only came into force in 2007 and initially assessed substances individually, it is not surprising that there was insufficient regulation for PFAS, a group consisting of thousands of different substances. It is therefore not surprising that regulations and guidelines for PFAS were insufficient prior to 2013. REACH can regulate specific uses of hazardous substances, such as PFAS in firefighting foam (European Chemicals Agency, 2023), and by introducing restrictions on this use, it can prevent future spread. If such a restriction had been introduced earlier, it would have prevented the spread in Kallinge, at least after the REACH decision was made. Another thing is that even 12 years after Ronneby, PFAS still remains in firefighting foam. This indicates that the producing companies might have a strong position in the REACH process.

3.2.4 The Swedish Chemical Agency

The Swedish Chemicals Agency (KemI) states that they are responsible for rules on how PFAS may be used today within the framework of EU chemicals legislation, primarily REACH. They clarify that the Swedish Chemical Agency does not have a supervision role in the form of monitoring. The Swedish Chemical Agency asserted that they were assigned a new role in 2024, protecting drinking water from pollution through the revised EU Directive on Drinking Water Quality. As part of this, they explained that they are to guide Swedish companies applying for approval of substances used in materials that come into contact with drinking water.

The Swedish Chemical Agency claims that they do not hold any responsibility for monitoring or managing PFAS contamination in drinking water. However, they emphasize that they together with the Swedish Food Agency, published a report to urge water producers to investigate whether their water was contaminated with PFAS, and that it was published around the same time as the PFAS problem was discovered in Ronneby. They go on to explain that when it comes to responsibility for monitoring, many actors are involved. They state that the Swedish Environmental Protection Agency and the Swedish Marine and Water Authority coordinate Swedish environmental monitoring, and the Swedish Chemical Agency participates in a screening group run by the Swedish Environmental Protection Agency. They state that they have in several government assignments raised the need for increased environmental monitoring and particularly pointed out the importance of health-related monitoring, for example, in blood, umbilical cord blood, breast milk, and in the indoor environments of children and mothers.

They state that PFOS risk assessments were already conducted by them in 2004, which led to the substance being nominated for the Stockholm Convention in 2005. They point out that before Ronneby, the water source in Tullinge was taken out of use in the fall of 2011 due to high PFOS levels and that the PFAS contamination was discovered there by chance. The Swedish Chemical Agency noted that after learning about the connection between firefighting foam and PFAS, they discussed with the Swedish Food Agency in 2012 how they could raise awareness and promote more analyses done by water producers. They claimed that this resulted in a written advice for Sweden's water producers on investigating whether their water is contaminated with PFAS in collaboration with the Swedish Food agency in 2013.

The Swedish Chemical Agency also reports that the Ronneby case led them to take the initiative to form a network of authorities and a national PFAS network. They described that the purpose of the network is to improve coordination and to ensure information is shared between agencies and municipalities as PFAS spans the responsibilities of multiple authorities.

They add that the national PFAS network is run in collaboration with the Swedish Chemical Agency, the Swedish Food Agency, and the Swedish Environmental Protection Agency and that the purpose of the network is to strengthen and collect knowledge about PFAS, coordinate what is being done at the national level, and provide contacts and support for various actors (not least municipalities) in the country.

The Swedish Chemical Agency states that PFHxS was the PFAS substance found in the highest concentrations in people exposed to the contaminated drinking water in Ronneby. Based on this, they explained that the Swedish Chemical Agency proposed that the substance should be listed on the EU's so-called candidate list of particularly hazardous substances within REACH, and PFHxS is now included in the POPs Regulation.

According to the agency, flaws in monitoring were that the spread of PFAS to drinking water sources could continue for many years without being detected. They continued to say that an important factor is the assumption that groundwater contamination has primarily been associated with the use of pesticides, where the same chemical substance may be applied to limited areas over several years. They stated that to be able to predict the risk of widespread contamination, it was necessary to know what the firefighting foam contained, that even training foam included PFAS, and that the exercises were repeated in the same limited areas year after year. The Swedish Chemical Agency stated that more systematic groundwater monitoring is needed to confirm suspected contamination and emphasizing that substances can take many years to pass down to the groundwater, meaning that what we now see is due to previous “sins.”

They conclude that PFAS has long been a priority issue at the Swedish Chemical Agency. The example given included their nomination of PFOS to the Stockholm Convention in 2005 and the collaboration with the Swedish National Food Agency to produce written advice in 2013 to Swedish water producers on investigating whether their water is contaminated with PFAS. They reported having proposed several PFAS for restrictions and other regulations within the EU. Moreover, are informing they are working on a restriction proposal that includes all PFAS substances and four other European countries.

- Reflection, Commentary, and Summary of the Swedish Chemical Agency interview

The Swedish Chemical Agency had early knowledge of PFAS risks; they conducted a PFOS risk assessment as early as 2004 (Kemikalieinspektionen, 2004). However, their role was limited to policy and lacked operational oversight or authority, and implementing this knowledge in site-specific areas and relevant actors was not conducted. The agency’s risk assessment of PFOS and later involvement in policy networks reflect institutional awareness, but not sufficient urgency. Despite early warnings and international actions, national regulatory responses remained fragmented, and critical information did not reach municipal actors (Kaliber P1, 2019). This shows that having knowledge without any power leads to inaction. The formation of PFAS networks and REACH proposals after 2013 is important, although they sort of represent a reactive rather than preventive approach.

3.2.5 The Swedish Food Agency

The Swedish Food Agency states that it formulates regulations relating to drinking water, including LIVSFS 2022:12 and the former SLVFS 2001:30. However, they emphasize that their responsibility does not include monitoring water quality, which is the responsibility of the operator according to the applicable regulations. They clarify that there may be other monitoring requirements in environmental legislation, but that these do not fall within the competence of the Swedish Food Agency.

According to the agency, they have no direct responsibility for protecting drinking water from pollution. They refer to the Swedish Environmental Code, which places this responsibility on the polluting actor. They maintain that their regulation does not cover environmental protection in this regard.

They claim that their knowledge of PFAS before discovering the contaminants in Brantafors waterworks was limited but gradually increased. They stated that their involvement with PFAS began around 2008 when the European Food Safety Authority (EFSA) conducted a risk assessment, which formed the basis for the first action limits. They further noted that their involvement in the issue increased around 2010, and after the high levels of PFAS were discovered in Ronneby in 2013, recommended action limits for PFAS-7 were established in 2014 and PFAS-11 in 2016. They continued to inform that from 1 January 2026, the PFAS-4 and PFAS-21 limit values in LIVSFS 2022:12 and that testing for PFAS will be conducted if the hazard analysis indicates it is needed.

The Swedish Food Agency asserts that it is the operator who is responsible for monitoring and managing PFAS in drinking water. They explain that this means that the actor providing the water must investigate any risk substances in case of deviations from quality requirements or cases of suspicion of harmful levels and take the necessary measures. They emphasize that their role in managing PFAS has been advisory both before and after the events in Ronneby and that they have assisted with risk assessments. They clarify that they do not conduct any inspections of drinking water facilities themselves, that it is the municipality’s responsibility.

Identified shortcomings in monitoring are according to them, mainly related to the previously limited knowledge of PFAS. They argued that their responsibilities were fulfilled within their legal mandate and that there are no instances where they should have acted but they did not.

They clarify that operations producing drinking water more than 10 m³ daily are obliged to conduct hazard analyses, which may include PFAS if relevant. Regarding the inventory of risks in Kallinge before the PFAS problem became known, the Swedish Food Agency referred to previous answers and states that it is not within their responsibility to state whether such a risk inventory should have been carried out. They lastly stated that any legislation requiring a national risk inventory of water sources does not fall within their jurisdiction but may exist within the areas of other authorities.

➢ Reflection, Commentary, and Summary of the Swedish Food Agency interview

The Swedish Food Agency presented their role in PFAS-related issues as regulatory rather than operational. While they are responsible for establishing drinking water regulations (LIVSFS 2022:12), they underline that the responsibility for monitoring water quality lies with the operator. Prior to 2013, PFAS was not included in the Swedish Food Agencys recommended analysis parameters for drinking water. An awareness of PFAS began to grow around 2008 following a risk assessment from

EFSA. Their involvement increased after PFAS was detected in Tullinge in 2011 and then Ronneby in 2013, leading to recommended action levels for PFAS (Ullman, 2015).

In response to the Ronneby case, they issued guidance (PM 5/13) to drinking water producers, highlighting firefighting foam as a potential contamination source with the Swedish Chemical Agency (Kemikalieinspektionen & Livsmedelsverket, 2013). These efforts also demonstrate a reactive rather than preventive approach and that critical knowledge about PFAS did not reach municipal actors. Even if their following work on action levels and guidance has been important, these efforts demonstrate a reactive rather than preventive approach, and that critical knowledge about PFAS did not reach municipal actors.

The descriptions of these actors highlight a broad distribution of roles, inadequate information transfer, and limited authority. However, which of these actors had the direct responsibility, a formal or practical mandate, to prevent, detect, or manage the risk in time? The following section focuses on actors who could have influenced the events before the harm occurred.

3.3 What actors had a direct responsibility for the contamination in Ronneby

This section analyses which actors were directly responsible for the PFAS contamination in Ronneby. Direct responsibility refers to a formal or practical mandate to prevent, identify, or address the risk of contamination, and thus also an actual opportunity to influence the course of events. The three actors that are particularly highlighted are Ronneby Municipality (incl. Miljö & Teknik AB), the Swedish Armed Forces, and ECHA/REACH. Although several other authorities had relevant roles after the discovery, these three had the opportunity to act before the damage occurred.

3.3.1 The municipality

Ronneby Municipality was responsible for the drinking water supply to the residents through the municipal company Miljö & Teknik AB. According to the previous food legislation, SLVFS 2001:30 (Livsmedelsverket, 2001) and to Ch2 §2 of the Environmental Code (SFS 1998:808, 1998), operators must provide safe water and take precautionary measures in the event of a risk of environmental or health damage. PFAS was not required to be analyzed at the time, as the substance was not included in the Swedish Food Agency's recommended guidelines.
Before the discovery of PFAS contamination in Ronneby in 2013, several guiding documents and warning signs could have motivated the municipality to conduct a more comprehensive risk inventory, especially since the drinking water plant was close to the Blekinge Air Force and its fire training activities. Kemikalieinspektionen (2004), published a risk assessment of PFOS, mentioning the toxicity, persistence, and potential for bioaccumulation, and in Appendix 3 of this report, they mentioned that elevated levels of PFOS were found in Lake Mälaren, near a fire training site. The Swedish Environmental Protection Agency addressed this in 2008 in a handbook for airports, stating that a fire-training site, when using firefighting foam, is an activity that releases substances to land and water (Naturvårdsverket, 2008). Additionally, Naturvårdsverket (2010), came out with a handbook on water protection areas, stating that risk analyses must include existing and potential sources of pollution. Which applied to the Ronneby case, as the waterwork in Kallinge is a water protected area having the fire training site nearby. A risk inventory for the relevant water protection area was carried out in 2012. However, the air fleet training area was not assessed as a source of risk

at that time (Ullman, 2015), even though firefighting foam containing PFAS has been used regularly in that area since the 1980s.

3.3.2 The Swedish Armed Forces

The Armed Forces were the direct source of PFAS contamination through the long-term use of PFAS-based firefighting foam during exercises carried out by Blekinge Air Force Base exercises. The Swedish Armed Forces are covered by Chapter 26, Paragraph 19 and therefore have a requirement for self-control to continuously monitor and plan their activities to prevent negative impacts on the environment and health (SFS 1998:808, 1998). However, this did not happen. Before the problem was brought to attention in 2013, there was no documentation of monitoring the release of firefighting foam into soil and water, risk assessments of firefighting foam, or groundwater monitoring. Instead, the Swedish Armed Forces relied on safety data sheets that lacked warnings about long-term effects, even though the risks of PFAS substances had been known to manufacturers such as 3M since the 1970s (Carrington, 2025). In 2008, the Swedish Environmental Protection Agency published a handbook for environmental considerations at airports, emphasizing the need to investigate risks from fire extinguishing agents (Naturvårdsverket, 2008), and should have been a guiding example for them. The Swedish Armed Forces responsibility also falls under Chapter 10, Paragraph 2 of the Environmental Code, which states that the operator responsible for the contamination must pay for the remediation.

3.3.3 REACH

The third actor is the European Chemicals Agency (ECHA), responsible for applying the REACH Regulation (EC 1907/2006). REACH requires manufacturers and users to ensure that chemicals do not harm health or the environment and that relevant risk information is provided in safety data sheets. In practice, however, a substance by substance perspective was applied, which meant that only certain PFAS (such as PFOS) were regulated early (Bock & Laird, 2022), while others, such as PFHxS, continued to be used. The substance by substance approach was used due to the individual assessment requirements under the REACH regulation ((European Parliament and Council, 2006b), (Articles 6, 10, and 68)), the lack of comprehensive toxicological data, and the substantial chemical variety within the group of PFAS substances (European Chemicals Agency, 2025a).

This led to no restrictions regarding using the firefighting foam in Ronneby despite its environmental hazards. Safety data sheets also contained no information on persistence, toxicity, or risk of dispersion. At the same time, the EU Water Framework Directive (Direktiv 2000/60/EG 2000) was already in effect aiming to prevent the deterioration of water quality. However, PFAS was not listed as a priority substance, meaning it was not included in monitoring requirements. It is with the new Drinking Water Directive (Direktiv 2020/2184, 2020) that the requirements for monitoring PFAS groups in drinking water will come into effect in 2026.

These three actors were legally responsible for preventing, detecting, or acting against PFAS contamination in Ronneby. The municipality failed in risk analysis and self-control. The Swedish Armed Forces lacked internal control routines and failed to apply guidance from the Swedish Environmental Protection Agency. ECHA's regulatory framework was too slow and fragmented to capture broad chemical groups such as PFAS. Although REACH did not come into effect until 2006, the REACH system demonstrates that the process of regulating chemicals is slow.

Chapter 26, Paragraph 19 of the Environmental Code could have been a strong tool for the Swedish Armed Forces, but their control requirements were not followed. At the EU level, REACH and the Water Framework Directive show that even well-developed regulatory frameworks can become insufficient when new environmental risks are not managed proactively.

3.4 Actor analysis – Responsibilities, actions, and systemic gaps

The PFAS contamination in Ronneby has highlighted several limitations in handling responsibility, supervision, and coordination between Swedish authorities and organizations. The following part analyzes the role of each key actor before, during, and after the discovery in 2013. The aim is to highlight the system's strengths and weaknesses in managing persistent environmental toxins.

3.4.1 Swedish Armed Forces

The Swedish Armed Forces were the direct source of the PFAS contamination due to the long-term use of PFAS-based firefighting foam during training exercises at the Blekinge Air Force base("T 486-23,," 2023). Firefighting foam was regularly used from the 1980s onward, without collection systems or environmental controls. During the fire training, a lot of foam leaked into the surrounding area. In Kaliber P1 (2019) former employees reported about exercises where foam was spread in the terrain and was used in considerable amounts ("up to the knees"), and that during some periods, the equipment was tested every week near a stream and not collected. The Swedish Armed Forces discovered PFAS in groundwater in 2008 at F14 in Halmstad. Consequently, within the Swedish Armed Forces, it was recognized that the firefighting foam could have contaminated the drinking water in Ronneby (Kaliber P1, 2019).

In 2006, PFOS was regulated at the EU level, and in 2008, PFOS was banned in new products, including firefighting foam. However, existing firefighting foam containing PFOS was permitted for use until 2011 (Direktiv 2006/122, 2006; Försvarets materielverk, 2014).

The Swedish Armed Forces primarily relied on safety data sheets (SDS) that lacked information about the long-term environmental and health effects of PFAS (Kaliber P1, 2019). However, several indicators suggest that the Swedish Armed Forces should have been aware of the risks. Elevated PFAS levels had already been found by the former called "Generalläkaren" the supervising authority at the Swedish Armed Forces (Enander, 2016), in groundwater at F14 in Halmstad in 2009, another military site, indicating that the issue was known within the organization before the discovery in Ronneby (Naturskyddsföreningen, 2022). In 2019, an investigation by (Kaliber P1) revealed that internal suspicions of PFAS contamination in Kallinge existed, although the information was neither communicated nor acted upon, showing shortcomings in internal risk management.

After PFAS contamination was discovered at the Brantafors waterworks in 2013, the Swedish Armed Forces stopped using PFAS-based foam in the area, they closed the training site, and sealed the wastewater system, to protect additional spread or leakage of PFAS-contaminated water into the surroundings.

Environmental investigations were initiated by the Swedish Armed Forces, identifying over 35 potential contamination sources, several of which are now subject to remediation efforts (Feldtmann, 2025).

Prior to 2013, there were no self-monitoring systems, violating the Environmental Code's requirements for self-inspection and preventative action (Chapter 10, Paragraph 2 and Chapter 26, Paragraph 19) (SFS 1998:808, 1998).

3.4.2 Ronneby Municipality / Ronneby Miljö & Teknik AB

According to the regulations in force at the time (SLVFS 2001:30) and the Environmental Code (1998:808), operators who produced and distributed drinking water were required to ensure the water was healthy and clean. The regulations required operators to keep an eye on water quality themselves. This meant regularly testing and checking the water, keeping track of the results, and acting if anything did not meet the required standards. This responsibility was also based on the precautionary principle of the Environmental Code, which requires that everyone who carries out an activity should take the protective measures necessary to prevent or counteract damage to human health or the environment (Livsmedelsverket, 2001; SFS 1998:808, 1998).
Before 2013, a risk inventory was carried out for the water protection area. However, the training site at Blekinge Air Force Base was not identified as a possible source of pollution despite the long-term use of firefighting foam in the area (Ullman, 2015).
At the time of the contamination, PFAS was not included in the Swedish Food Agencys recommended analysis parameters for drinking water. Miljö & Teknik AB followed these guidelines and had, therefore, not tested the water for PFAS.
After the discovery, Brantafors Waterworks closed immediately. The municipality informed the public and initiated sampling. New water sources were put into use, and carbon filters were installed to purify the municipal drinking water. Subsequently, the Ronneby municipality improved its risk management procedures and introduced regular sampling of PFAS in the water (Ronneby Kommun, 2024a).

3.4.3 REACH

The European Chemicals Agency (ECHA) implements and administers the REACH Regulation (EC 1907/2006), setting up requirements for the registration, evaluation, and restriction of chemicals. They facilitate the implementation of EU chemicals legislation by offering scientific expertise, collaborating with EU institutions, member states, and international organizations, as well as providing guidance to industry stakeholders. They are a source of information to interested parties (European Chemicals Agency, 2025b).

Safety data sheets for firefighting foam rarely contained information regarding PFAS and its long-term environmental and health effects. Safety data sheets from 1991 (and earlier) regarding PFAS substances were incomplete, lacking information about their toxicological and environmental risks. Before 2013 most PFAS substances were not classified as hazardous, missing vital information about the effects PFAS had on long-term health risks and environmental impacts (Bock & Laird, 2022; European Council, 1991). ECHA's work before 2013 and the application of the REACH Regulation on PFAS mainly focused on individual substances, such as PFOS and PFOA, which were identified as particularly hazardous due to their persistence, bioaccumulation, and toxic properties(Bock & Laird, 2022).

After 2013, changes have been made by ECHA and the EU in their approach to handling PFAS, and instead of focusing on the substances' individual risks, the focus is now on class-based restrictions covering all PFAS, regardless of their risk profile. This new focus aims to reduce the long-term environmental impact, prevent the continued accumulation of PFAS in nature, and prevent replacing hazardous substances with others that have properties and risks comparable to PFAS (Bock & Laird, 2022; European Chemicals Agency, 2022).

3.4.4 Swedish Chemicals Agency

The Swedish Chemicals Agency (KemI) had some knowledge of the environmental risks of the PFAS group before 2013. In 2000, the Swedish Chemicals Agency was warned about PFOS, from the U.S. EPA, stating that it is toxic, persistent, and tough to break down and that it should be phased out to protect the environment and human health (Kaliber P1, 2019). As early as 2004, the authority carried out a risk assessment of PFOS (Kemikalieinspektionen, 2004). Despite this early knowledge, the information did not reach municipal actors or water producers. There is no information about the Swedish Chemical Agency informing other major users of PFOS directly, and PFAS were not included in any systematic environmental monitoring.

After the discovery in Ronneby in 2013, the Swedish Chemical Agency acted with the Swedish Food Agency by publishing guidance material (PM 5/13) to Swedish water producers on firefighting foam as a potential source of contamination of drinking water (Kemikalieinspektionen & Livsmedelsverket, 2013). The agency also took the initiative for collaboration platforms such as SamTox and a national PFAS network. In addition, the Swedish Chemical Agency has worked on proposing new PFAS substances to the REACH candidate list, which now includes PFHxS (Kemikalieinspektionen, 2020).

The agency has no operational supervisory role but has participated in coordination efforts and advocated for EU regulatory actions concerning PFAS use(Kemikalieinspektionen, 2025a). Despite early knowledge, no structures were in place to promptly translate this into concrete measures before 2013.

3.4.5 The Swedish Food Agency

The Swedish Food Agency evaluates the risks of PFAS in drinking water and food, establishing regulations with limit values for chemical substances and self-monitoring requirements that drinking water producers must follow. The Agency also provides recommendations on how to manage the risks. The recommendations are aimed at drinking water producers, local control authorities, and small drinking water producers for private use (Kemikalieinspektionen, 2025a).

In 2013, there were no legally binding limit values for PFAS in drinking water, and it was decided that the Swedish Food Agency would develop action limits. The aim was to provide drinking water producers and control authorities with clear guidance on what levels of PFAS in the water could pose a health hazard and avoid situations with individual risk assessments in each case (Ullman, 2015).

The Swedish National Food Agency's involvement in the contaminated drinking water in Kallinge was to conduct a risk assessment and support the municipality with guidance and knowledge to enable them to manage the situation independently, as well as offer advice or recommend risk management measures (Ullman, 2015)

The Swedish National Food Agency was well prepared for PFAS Kallinge drinking water as it had a good knowledge base, had previously initiated work on PFAS, and developed general risk assessments after discovering that drinking water in Uppsala was contaminated with PFAS (Ullman, 2015).

3.4.6 Swedish Agency for Marine and Water Management

The Swedish Marine and Water Authority is responsible for guiding water authorities and county administrative boards in assessing the environmental status and establishing environmental quality standards for water, including limit values and assessment criteria for PFAS substances such as PFOS and PFOA. The authority also regularly assesses the marine environment's state and trends in biota-hazardous substances, including PFAS, to ensure that threshold values are not exceeded and that concentrations decrease over time. It also guides the work in water protection areas and is responsible for the environmental monitoring of the sea, inland waters, and groundwater (Kemikalieinspektionen, 2025a).

After the PFAS discovery in Ronneby, the Swedish Water Authority began participating in the national monitoring of PFAS in surface and groundwater. The authority is now part of collaborative bodies with other authorities, such as the Swedish Environmental Protection Agency and the Swedish Water Authority, including within the framework of the Toxicological Council. The work includes coordination on the monitoring of particularly hazardous substances in aquatic environments.(Henning, 2025).

3.4.7 Swedish Environmental Protection Agency

Before the discovery of extensive PFAS contamination in Kallinge/Ronneby in 2013, the Swedish Environmental Protection Agency had a relatively limited and indirect role in the work with PFAS. In 2001, the Swedish Environmental Protection Agency initiated a broad environmental monitoring program (screening) that included measurements of PFAS in fish, sediment, surface water, and leachate from landfills.

However, the focus was mainly on surface water and biota, and the importance of groundwater contamination, linked primarily to drinking water sources, received little attention. Before 2013, groundwater sampling for PFAS was conducted on an occasional basis, and the resulting data were not systematically communicated or integrated within the framework of governmental environmental monitoring programs. Overall, the Swedish Environmental Protection Agency had some knowledge about the risks of PFAS, but this knowledge was not translated into effective preventive work, and communication about the risks to water producers and the public was inadequate. (Enander, 2016).

Today, they have a central role in managing PFAS and supporting and coordinating measures to reduce the spread of PFAS in the environment. The agency is responsible for developing guidance and coordination between different actors to achieve environmental quality goals such as a non-toxic environment and good-quality groundwater. In addition, the Swedish Environmental Protection Agency proposes measures to develop environmental work and ensure that the generational goals for the environment are achieved (Naturvårdsverket, 2024b).

3.4.8 County Administrative Board of Blekinge

Before the discovery of PFAS contamination in Kallinge/Ronneby in 2013, the County Administrative Board had limited and fragmented responsibility for the PFAS issue, even though they were formally regulatory authorities under the Environmental Code for certain types of activities, including fire training sites, although not for the Swedish Armed Forces fire training sites (Enander, 2016). PFAS was not identified as relevant in environmental monitoring or regulatory programs. Instead, the focus was on other substance groups, such as heavy metals and organic pollutants (Andreasson, 2025).

The County Administrative Board works actively today with PFAS by conducting sampling of surface and groundwater as part of environmental monitoring and requiring permit-holding businesses suspected of using PFAS, such as fire training areas and industries, to carry out sampling. The board also participates in the permitting process for environmentally hazardous activities, where they can impose conditions to limit PFAS emissions, such as wastewater treatment requirements. Additionally, the County Administrative Board is advisory to municipalities regarding oversight and assessment of PFAS impact and environmental risks (Kemikalieinspektionen, 2025a).

3.4.9 Summary of actor responses to PFAS contamination in Ronneby

To provide an overview of the roles and actions of the various actors in connection with the PFAS contamination in Ronneby, their responsibilities, efforts and changing positions over time are summarized here. Table 2 synthesizes each actor's actions before and after the discovery of the contamination, as well as key actions taken and relevant sources. The table complements the actor-specific analysis above.

Tabell 2: Summary of Actor Responses to PFAS Contamination in Ronneby

Actor	Key role/actions before 2013	During	Key actions post 2013	References
Swedish Armed Forces	PFAS-based foam was used without implementing environmental safeguards, and reliance was placed on incomplete or inadequate safety data sheets. No environmental monitoring was conducted.	Closed the training site and stopped PFAS usage in that area. Investigations regarding PFAS contamination at their fire training sites were launched.	Working on finding PFAS-free foam, ongoing environmental engineering investigations, and actively collaborating with other actors in purification and remediation methods.	(Försvarsmakten, 2022; Försvarsmakten & Miljöprövningsenheten, 2016; Kaliber P1, 2019)
Ronneby Municipality / Ronneby Miljö & Teknik AB	Risk assessment conducted in 2012; however, the fire-training site was not identified as a potential source of PFAS contamination. PFAS was not in the list of substances to be analyzed. Followed the Swedish Food Agency's checklist.	Brantafors' waterworks immediately shut down. Sampling of water and information provided to the public.	New water sources, carbon filters installed, and continuous sampling. Risk management practices were improved.	(Ronneby kommun, 2024b; Ullman, 2015)
REACH	PFOS: restricted, lacked regulation on other PFAS. Focus on individual substances.	/	Proposal for banning PFAS in firefighting foams.	(European Chemicals Agency, 2024b)
Swedish Chemicals Agency	Conducted risk assessment of PFOS 2004. Knowledge existed, but did not reach the local municipality.	In 2013, the Swedish Chemicals Agency and the Swedish Food Agency published PM: 5/13—Firefighting Foam as a Potential Contaminant of Drinking Water Sources. Participation in the coordinated investigation to map the cause and management of PFAS.	Initiated inter-agency networks, advocated for an EU-wide ban, and established collaboration functions; SamTox and the Toxicological Council are aiming to ensure rapid and systematic information sharing and	(Kaliber P1, 2019; Kemikalieinspektionen, 2020; Ronneby Kommun, 2024a; Ullman, 2015)

			coordinated action among responsible authorities in response to serious chemical threats.	
Swedish Food Agency	PFAS were not included among the substances that were routinely required to be tested according to the Swedish Food Agency's regulations, limited international coordination.	Conduct a risk assessment. Supporting the municipality with advice and knowledge. Propose threshold values.	Developed limit values (PFAS-4/11/21). Continued collaboration and regulatory guidance.	(Ullman, 2015)
Swedish Agency for Marine and Water Management	Guiding authority for assessing the environmental status of water.	/	Expanded the monitoring of PFAS in surface and groundwater. Collaboration with, for example, the Swedish Environmental Protection Agency, county administrative boards, and the Geological Survey of Sweden (SGU) regarding the monitoring of hazardous substances in the aquatic environment. Involved in the Toxicological Council.	(Henning, 2025; Kemikalieinspektionen, 2025a)
Swedish Environmental Protection Agency	Finance national environmental monitoring in Sweden. Oversees national environmental monitoring in Sweden, supporting authorities and operators in applying the Environmental Code.	/	The Swedish Environmental Protection Agency was tasked by the government in 2015 to investigate the presence of PFAS in Swedish waters. In 2019, in collaboration with the Swedish Geotechnical Institute (SGI), they	(Kemikalieinspektionen, 2025a)

			developed joint guidelines on how per- and polyfluoroalkyl substances (PFAS) can be risk assessed and remediated at contaminated sites.	
County Administrative Board of Blekinge	Coordinating regional efforts on contaminated sites, guiding municipalities, conducting inspections, prioritizing remediation projects, and allocating or recommending state funding for the most urgent cases.	Played a central role in coordinating response after discovery. Helped initiate testing, public communication, and inter-agency dialogue.	Actively supporting the municipality with sampling and risk assessment, improved communication between authorities, influenced policy and regulations.	(Andreasson, 2025; Naturvårdsverket, 2024d)

3.5 International and national warning signs: Ronneby was not the first PFAS case.

Even though Ronneby has become Sweden's most high-profile PFAS case, it is far from the first. It is important to place the events in Ronneby in a broader context to better understand the actors' background for action and whether the contamination could have been prevented. This section presents five case studies of earlier PFAS pollution detected in Sweden and internationally. These cases provide valid points of comparison to identify recurring patterns of delayed actions, knowledge gaps, and weaknesses in regulation.

3.5.1 Case study: PFAS contamination at F14 airbase, Halmstad (Sweden)

In Halmstad, PFAS had leaked from the military's training site into the Mickedala water source. The contamination was traced to using PFAS-containing firefighting foam during exercises at the military base. According to the investigation by Enander (2016), high levels of PFOS were found in groundwater sampling in 2008 in connection with periodic supervision. The report further states that Generalläkaren raised concerns at the fire training site in Halmstad in 2009 and expressed difficulties in obtaining guidance from central authorities, particularly the Swedish Environmental Protection Agency and the Swedish Chemical Agency.

PFAS has long been a significant component of firefighting foam, but its adverse effects on health and the environment were not fully understood then.

Although the Municipality of Halmstad was aware of the elevated PFOS concentrations in the groundwater, there were no remedial measures taken. Due to a lack of awareness, neither the municipality nor the military took any action until PFAS was detected in other locations in 2011 (P4 Halland, 2019). Although this was one of Sweden's earliest known PFAS cases, it was treated as an isolated problem. No systematic mapping of PFAS in soil or water was initiated, and the incident passed without generating broader discussion about regulation or liability.

The lack of action following early PFAS detections in Halmstad illustrates a missed opportunity to strengthen national oversight, which may have delayed recognition and preventive action in Ronneby.

3.5.2 Case study: PFAS contamination at Peterson Air Force Base (USA)

Peterson Air Force Base (PAFB), established in 1942, is situated in Colorado Springs, Colorado, where it also was the location for U.S. space operations through the 21st Space Wing (Aerostar SES LLC, 2017). PAFB started using firefighting foam in the 1970s. Firefighting foam was used extensively at the base, causing PFAS spreading to the groundwater leading to widespread contamination over the years. Concerns regarding PFAS pollution at the base began to rise in the late 2010s, prompting for federal and state-level investigations and in response water testing was initiated at the base in April 2016. In November 2017 PFAS was found at levels 1000x the national average (Robert, 2025). Leaders at the PAFB base had previously admitted to dumping wastewater contaminated with firefighting foam into Colorado Springs sewers several times a year, which increased the likelihood for the water to reach the Widefield Aquifer, Fountains main water source. However, even if the releases was acknowledged it was downplayed to be a contributor for the contaminated drinking water (CPR News Staff and The Associated Press, 2017). In September 2019 lawsuits were filed against PAFB by people being affected by health issues caused by the PFAS exposure, which has been linked to kidney cancer, testicular cancer, thyroid disorders, and developmental delays in children. Health issues linked to the contaminated water at PAFB include cancer, thyroid disorders, and developmental problems in children. People exposed to the contaminated water are encouraged to do regular health screenings and assessments (Robert, 2025). 80.000 people in south of Colorado Springs had their water contaminated from PAFB using firefighting foam containing PFAS, with levels above what the Environmental Protection Agency (EPA) classified as safe (Finley, 2016). Recent revies of the water quality at PAFB show that concentrations of PFAS exceeding the EPAs health limits. There are ongoing efforts to monitor and sampling the water supply to ensure limits are under control (Robert, 2025).

Just like in the Ronneby case, this case represents how extensive use of firefighting foam contributed to contaminated drinking water, exposing many people to potential health risks. Just like Ronneby, the contamination could remain undetected for many years, which clearly shows limitations in the environmental monitoring, regulatory oversight, and chemical risk assessment.

3.5.3 Case study: PFAS contamination at Oakey Army Aviation Centre, Australia

In the Oakey Centre in Queensland, Australia PFAS (mainly PFOS and PFOA) from firefighting foam were used by the Army Aviation stretching from 1970 until 2005 (Friends of the Earth Australia, 2024; Roe, 2016a). PFAS substances then continuously leaked into the soil and contaminated the groundwater, leading to other areas being contaminated. In 2016, the Department of Defense reported that residents who had used well water before 2010 were likely exposed to these chemicals (Roe, 2016b). As early as 1991, the Department of Defense was aware of the possible dangers of firefighting foams (Knaus, 2017). PFAS was monitored by the Defense Department since 2006, and it was confirmed as an issue at Williamtown base in 2011 and Oakley in 2013.

National Industrial Chemicals Notification and Assessment Scheme (NICAS) was recommended in 2003 to restrict the use of PFOS/PFOA (components in firefighting foam AFFF) to essential use only. This, however, did not prompt the Australian water authorities to begin testing water for PFAS. The first monitoring of PFAS in drinking water was conducted in 2009 by the authorities. This late recognition of the importance of testing for PFAS in water, despite growing facts, led actors to miss the early warning signs, contributing to ongoing contamination (Friends of the Earth Australia, 2024). Residents and businesses have since taken legal action against the state, including a class action lawsuit from 450 people and a lawsuit from a local slaughterhouse seeking $47 million in compensation for economic losses. (Bradfield & Morris, 2020).

Like Ronneby, Oakey involved long-term military use of PFAS foam and the late discovery of contamination, underlining how institutional inertia and unclear responsibility can extend public exposure.

3.5.4 Case study: PFAS contamination in Tullinge/Uppsala (Sweden)

In 2011, Stockholm University held a summer school for high school students. The students took samples of their tap water from home. It turned out that one student from Tullinge had very high PFAS levels in his water. Further tests showed that the deserted military airfield in Tullinge was the source of contamination.

Around the same time, the Swedish National Food Agency discovered that new mothers in Uppsala had rising PFAS levels in their bodies. The contaminated water source in Tullinge led the Swedish National Food Agency to suspect that the water could also be contaminated here. To confirm the suspicions, employees of the Swedish National Food Agency had their tap water sampled in the spring of 2012. It turned out that high levels of PFAS were found in the southern and western districts of the city.

The Swedish National Food Agency started to suspect PFAS in drinking water thanks to the event in Tullinge, which was a starting point for finding very high PFAS levels in Ronneby's municipal drinking water. (Uppsala nya tidning, 2021).
In Uppsala, the legal proceedings focused on environmental remediation under the Environmental Code, whereas in Ronneby, lawsuits concern personal injury that claims under the Product Liability Act. (Uppsala Vatten och Avfall AB, 2025; VA-guiden, 2024).
This case demonstrates how early detection and institutional suspicion, although not immediately acted upon, could have served as a warning sign before the more extensive contamination in Ronneby.

These cases of PFAS contamination exhibited repeated signs of delayed reactions, vague responsibilities, and limited understanding of PFAS and its management. They show that even though experience from other locations exists, exposures occur again and again. With that said, by comparing PFAS with historical environmental problems like DDT and PCB, we can better understand why society sometimes fails to act even when the risks are known.

3.5.6 Case Study: PCB and DDT

Historical cases such as DDT (Dichlorodiphenyltrichloroethane) and PCBs (Polychlorinated Biphenyls) offer important parallels to the current PFAS crisis. DDT, introduced in the 1940s as a pesticide, and PCBs, used widely in industrial applications from the 1930s onwards, were initially praised for their benefits. However, both substances later proved to be extremely persistent, bioaccumulative, and toxic to humans and ecosystems (Breivik et al., 2002; Carson, 1963). Early scientific warnings about DDT and PCBs emerged several decades before regulatory actions were taken.

Polychlorinated biphenyls (PCBs) are chlorinated organic compounds. They were first synthesized in the laboratory in 1881, and mass production for commercial use began in 1929. PCBs are the first clear example of a substance that was not intentionally released into the environment but spread widely and bioaccumulated to high concentrations. As early as 1899, a pathological condition called chloracne had been identified, a painful, disfiguring skin disease that affected people employed in the chlorinated organics industry. Chloracne and liver damage were observed in experiments with rats in 1937. The first well-known warning that PCBs could be harmful to humans came from an accident in 1968 in Japan, known as the Yusho accident, in which 1,800 people were poisoned after ingesting contaminated rice bran oil. The information that PCBs could poison humans existed as early as the 1930s, but remained mainly within industry. Although the Yusho accident in 1968 provided a high level of evidence that PCBs could cause serious harm, and Søren Jensen's findings in 1969 clearly showed bioaccumulation in the Baltic Sea food chain, actions were delayed. It was not until the late 1970s that legislation was enacted to ban the manufacture and use of PCBs. (Harremoës et al., 2001). Even though the use of PCBs has been forbidden for a long time, they are still spread into the environment through buildings and specific electrical equipment today (Naturvårdsverket, 2025).

DDT (dichloro-diphenyl-trichloroethane) was the first synthetic pesticide created in the 1940s. DDT proved to be an effective agent in the control and prevention of diseases, e.g., malaria and typhus. Furthermore, it was also effective for managing insects in gardens, institutions, homes, and the production of crops and cattle (U.S. Environmental Protection Agency, 2025). Research in the 1950s revealed that DDT caused eggshell thinning among birds, leading to sharp declines in bird populations (Carson, 1963). In chapter 7 of Silent Spring, she tells, among other things, about the aerial spraying

of DDT and other pesticides in Detroit and over Long Island in New York in connection with the control of Japanese beetle and Gypsy moth, and how immediately after the spraying, people in Detroit began calling about large numbers of dead and dying birds.
Rachel Carson reminds her readers in her book Silent Spring that the opportunities to identify warning signals should have been seized much earlier, with 10 % of bird species threatened worldwide in some way, and this was over 60 years ago (Carson, 1963; Gee et al., 2013).
Despite early warning signs of DDT's negative effects on bird reproduction, it was not until 1970 that the substance was banned in Swedish agriculture. A complete ban did not come until 1975. Other Western European countries and the United States followed with similar measures, but DDT is still used in some parts of the world, allowing the substance to be spread by the winds to other areas of the world (Sveriges lantbruksuniversitet, 2022).
DDT, PCBs, and PFAS have the common trait of being persistent in the environment. This means that they break down very slowly or not at all, accumulating in the food chain and causing serious and long-term effects on the environment and living organisms.

3.6 Laws and regulations

The PFAS contamination in Ronneby highlights crucial questions of legal responsibility, preventive measures, and regulatory oversight. Analyzing the legal framework that existed before, during, and after the discovery of the contamination is important to better understand why certain actors acted or failed to act in time. This section summarizes the key national and international laws and regulations applicable then and discusses their connection with the actors involved in managing the PFAS issue in Ronneby.

Table 3. The most important laws and regulations relevant to managing PFAS contamination in Ronneby.

Law/regulation	**Main content**	**Relevance to Ronneby**	**Reference**
Chapter 2, Paragraphs 2-3-4, Environmental Code	Precautionary principle (2 §), product choice principle (3 §), and (4§) take measures to avoid the use of chemical products that are suspected to pose risks to human health and the environment.	Actors should have prevented PFAS contamination and substituted hazardous substances	(SFS 1998:808, 1998)
Chapter 10, Paragraph 2, Environmental Code	“Polluter pay principle”	Can be connected to the Swedish Armed Forces.	(SFS 1998:808, 1998)
Chapter 26, Paragraph 19, Environmental Code	Anyone conducting activities that may harm human health, or the environment must continuously plan, monitor, and stay informed to prevent or counteract such effects.	Lack of self-monitoring by the Swedish Armed Forces.	(SFS 1998:808, 1998)
REACH Regulation (EC 1907/2006)	Regulation of chemicals, early restriction of PFOS.	The Swedish Armed Forces should have complied with this regulation by	(European Parliament and Council, 2006b)

		stopping using PFAS foam once the risks were known.	
Product Liability Act (1992:18), 2 §	If PFAS or other harmful substances are present in the water at levels that make it unsafe for consumption, it can be considered a product with a safety deficiency.	Ronneby Miljö & Teknik could be held liable for contaminated water	(Nytt juridiskt Arkiv, 2018; Sverige, 1992)
Ordinance (2008:245) on Chemical Products and Biotechnical Organisms. Chapter 14, Environmental code	It governs safe use, risk assessment, and regulation of hazardous substances to protect health and the environment.	Central to address the legal aspects of PFAS contamination and ensure that those who have caused harm take action to protect health and the environment.	(Riksdag, 2008; SFS 1998:808, 1998)
(SLVFS 2001:30)	Established drinking water quality requirements according to specified microbiological and chemical parameters.	PFAS were not included in the required parameters, meaning; water utilities were not required to analyze for these substances.	(Livsmedelsverk, 2001)
Stockholm Convention (POPs Convention)	The Stockholm Convention is a global convention to protect human health and the environment from persistent organic pollutants. PFOS has been included in the Stockholm Convention since 2009.	PFOS use in firefighting foam is globally allowed without any time limitations.	(Kemikalieinspektionen, 2016)
Swedish EPA Handbook (2008)	Points to the environmental risks of PFAS-based firefighting foam at airports and military facilities and offers guidance on managing and preventing these risks.	Recommendations that could have prevented contamination.	(Naturvårdsverket, 2008)
Drinking Water Directive 98/83/EC	Requirement for decent and clean drinking water.	Basis for responsibility even before specific PFAS limits existed.	(Union, 1998)
Drinking Water Directive 2020/2184	New PFAS limits from 2026, maximum 0.5 µg/l for the sum of all PFAS substances in drinking water and 0.1 µg/L for the sum of 20 specific priority PFAS substances.	Improvements on future control of PFAS in drinking water.	(Direktiv 2020/2184, 2020)
LIVSFS 2022:12	Swedish PFAS limits in drinking water (4 ng/L).	Standards for good water quality.	(Livsmedelsverket, 2022)

Although the legal framework at both national and European levels contained several important principles and obligations for preventing environmental risks, examining it closer shows that there are limitations in both the construction of the legislation and in the practical application by the actors. Underneath is a short summary overview of how different systems failed and enabled the extensive PFAS contamination in Ronneby
At the national level, the Environmental Code (SFS 1998:808, 1998) contained important principles such as the precautionary principle (Chapter 2 §2) and requirements for self-monitoring (Chapter 26 §19), which meant that operators should take protective measures and continuously monitor their impact on the environment and health.
At the European level, chemical use was regulated by the REACH Regulation (European Parliament and Council, 2006b) which at the time covered some PFAS substances, such as PFOS, but not the entire group of substances. Drinking water regulation was governed by the Drinking Water Directive (98/83/EC) (Union, 1998), which set requirements for clean water but did not specify limit values for PFAS before the 2020 revision.
The Stockholm Convention included a global ban on certain uses of PFOS, but exemptions allowed its continued use in firefighting foam (Kemikalieinspektionen, 2016). At the organizational level the Swedish Armed Forces was responsible for conducting self-inspections and ensuring that the activities did not damage the environment (SFS 1998:808, 1998). Other authorities, the Swedish Chemicals Agency and the Swedish Marine and Water Management Authority, played more off a supportive and advisory role (Henning, 2025; Kemikalieinspektionen, 2025a) .

In conclusion, the review shows that existing legislation and regulations during the issue with high levels of PFAS in drinking water in Ronneby municipally provided opportunities to prevent risks but that the application and compliance with these requirements varied between actors.

3.7 Time axis of important events

To better understand the delay that characterized the management of PFAS risks, a timeline of important warning signals, scientific breakthroughs, and regulatory decisions is presented below. By following the development over time, it becomes clear how knowledge about PFAS environmental and health risks gradually grew, but also how this knowledge was not translated into preventive measures for a long time. The timeline thus highlights the opportunities to act earlier, and the occasions responsible actors chose to take a wait-and-see approach despite increasing evidence. This historical perspective is crucial for analyzing the structural shortcomings that made the Ronneby incident possible.

Table 4. Timeline of key warning signals, scientific breakthroughs, and regulatory decisions.

Event	Year/decade	References
PFAS was discovered by the company DuPont	1938	(Seymour & Kirschenbaum, 1986)
PFAS – widespread commercial use, Teflon, etc.	1950-	(Renfrew & Pearson, 2021)
Results from 3M and Dupont experiments on rats; PFAS is easily taken up by the blood.	1950	(Rosengren et al., 2024)

Study discovers: PFAS binds to proteins in human blood	1955	(Nordby & Luck, 1956)
DuPont acknowledged the potential risks of PFAS to human health and the environment, including wildlife.	1960	(Naturskyddsföreningen, 2023b)
PFAS-based firefighting foam was first created and patented by the US NAVY	1963	(Faber & Hayes, 2020)
Hans Palmstierna warned PFAS from firefighting foam - infiltrating the soil - leaching into groundwater.	1968	(Rosengren et al., 2024)
• An internal DuPont memo states that PFAS are “highly toxic when inhaled.” • A chemical company alerts the firefighting industry to the potential toxicity of PFAS to fish. • Firefighting foam with PFAS – used by civilian airports and fire departments.	1970	(Faber & Hayes, 2020)
Pregnant women were relocated at 3Ms facilities, due to harmful risk to fetus. Long time studies on rats were conducted.	1981	(Rosengren et al., 2024)
PFAS is found in drinking water for the first time.	1984	(Rosengren et al., 2024)
Results showed connection to cancer, higher dose resulted in more tumors in testicles, liver and pancreas.	1987	(Rosengren et al., 2024)
A study by 3M finds that exposure to PFOA. (C8) increases the risk of testicular cancer.	1990	(Faber & Hayes, 2020)
The Swedish Rescue Agency's report, "Effects of Foam Liquids on the Environment," found that PFAS did not degrade over 2.5 months and recommended limiting its use in fire drills. However, the agency continued to use PFAS-based foam without training its staff to prevent environmental contamination. Releases of foam liquids can cause acute environmental disruption.	1995	(Naturskyddsföreningen, 2023b) (Holm & Solyom, 1995)
The Department of Defense announced that 3M would cease producing PFAS-based firefighting foam due to the chemical PFOS being "bioaccumulative" and "toxic."	2000	(Faber & Hayes, 2020)
• EPA warned Sweden and others about the risks of PFOS, urging its phase-out. That	2000	(Naturskyddsföreningen, 2023b)

same day, 3M announced it would remove PFOS from all products. • The Swedish Chemicals Agency and the Swedish Environmental Protection Agency found low levels of PFOS in most surface water samples but did not consider PFAS contamination in groundwater. The Swedish Food Agency, responsible for regulating drinking water, received updates from other authorities, while fish samples from some lakes showed PFOS; however, drinking water sources and groundwater were not tested.		
Foam manufacturers are alerted that PFAS is "persistent, bioaccumulate, and toxic," and when all three characteristics are present, it constitutes a "death sentence."	2001	(Faber & Hayes, 2020)
High levels of PFAS were detected in surface water from Rosersbergsviken in Mälaren, which is linked to the Fire Rescue Service's training site in Rosersberg.	2001	(Naturskyddsföreningen, 2022)
FFFC (firefighting foam coalition) acknowledges that foam breaks down into PFOA but softens its risks.	2002	(Faber & Hayes, 2020)
Försvarets materialverk (FMV), decided to replace firefighting foam containing PFOS. They had until 2005-12-31 to clean their fire trucks and systems before implementing the new foam.	2003	(Försvarets materielverk, 2014; Ronneby kommun, 2025)
A draft report from the EPA Science Advisory Board classifies PFOA as a "likely human carcinogen."	2006	(Faber & Hayes, 2020)
Directive 2006/122, restricted the use of PFOS in products, including firefighting foam. Firefighting foam containing PFOS purchased before December 27, 2006, was allowed to be used until June 27, 2011	2006	(Direktiv 2006/122, 2006; Kemikalieinspektionen & Livsmedelsverket, 2013)
The EU decided to ban PFOS, and sales prohibited in June 2007.	2007	(Kaliber P1, 2019)
The Convention on Persistent Organic Pollutants (POPs) in Stockholm announced the restriction on the manufacturing and usage of PFOS and PFOS related substances based on perfluorooctane sulfonylfluoride.	2009	(Zhao et al., 2023)

Groundwater samples were taken at the F14 Halmstad air flotilla. Elevated PFAS levels were detected, prompting notification to the municipality.	2009	(Naturskyddsföreningen, 2022)
PFAS was found in Tullinge's drinking water, leading to the closure of the local plant and the subsequent supply of water to residents from an alternative source.	2011	(Naturskyddsföreningen, 2022)
The remaining stock of PFOS is no longer allowed to be used.	2011	(Försvarets materielverk, 2014)
A study found higher PFAS levels in mothers in Uppsala compared to those in Stockholm, prompting the Uppsala municipality to test its drinking water. High PFAS levels were detected at the Bäcklösa plant, which was immediately shut down. The primary source was identified as fire foam used by the defense.	2012	(Naturskyddsföreningen, 2022)
High levels of PFAS were detected at the Brantafors waterworks, resulting in its temporary shutdown.	2013	(Naturskyddsföreningen, 2022)
The Swedish Water Agency urged municipalities to test their drinking water sources for PFAS. Results showed contamination in 37% of surface water sources, 50% of artificial infiltration ponds, and 19% of groundwater sources.	2014	(Holmström et al., 2014)
The Swedish Food Agency identified 109 municipal facilities that were affected by PFAS, which supply drinking water to approximately 3.6 million people. An action limit was established for PFAS in drinking water.	2014	(Livsmedelsverket, 2014a)
Settlement with Minnesota: 3M paid 850 million dollars to settle a lawsuit accusing the company of contaminating groundwater with PFAS and knowing about the risks for over 40 years.	2018	(Type Investigations, 2018)
Denmark is implementing a new limit value for PFAS-4 at 2 ng/L. This means that the concentration of PFAS-4 in water should not exceed 2 nanograms per liter (ng/L	2022	(Naturskyddsföreningen, 2023a)
The Swedish Food Agency has established a new limit value of 4 ng/L for drinking water in Sweden, effective as of 2026.	2023	(Naturskyddsföreningen, 2023a)
National settlement in the US: 3M agreed to pay between $10.5 and $12.5 billion to help clean up	2023	(News, 2023)

PFAS contamination in public drinking water systems.		
The Swedish Society for Nature Conservation conducted a study to investigate PFAS levels in household drinking water nationwide. 92% of households had PFAS in their drinking water, with 11% exceeding the limit value.	2024	(Naturskyddsföreningen, 2023a)

The timeline reveals delayed responses, even when scientific evidence and early warning signals about the risks associated with PFAS increased. The timeline highlights several missed opportunities where earlier interventions could have limited the environmental and public health impacts of PFAS. These delays resulted more from fragmented responsibilities, insufficient regulatory frameworks, and institutional inertia than from a lack of knowledge.

3.8 Actor responsibility and system deficiencies - a summary of the results

The results section shows that several actors, local, national, and European had the opportunity to act earlier to prevent the extensive PFAS contamination in Ronneby. Although some knowledge about PFAS existed before 2013, this information did not reach the actors responsible for water supply or environmental supervision. Many authorities cited limited mandates, insufficient coordination, or a lack of clear legislation as reasons for inactivity.

The case studies from Halmstad, Tullinge/Uppsala, USA, Australia, and other parts of Sweden show that Ronneby was not a unique exception. On the contrary, the same pattern of late detection, uncertainty about the division of responsibilities, and lack of preventive supervision is repeated. In several cases, there were earlier warning signals that could have been used to increase preparedness, but these did not lead to systematic changes until after severe damage had already occurred.

The results show a structural weakness in managing persistent chemicals such as PFAS. There are no mechanisms to quickly convert new knowledge into regulation, the division of responsibilities is fragmented, and communication between authorities and local actors is insufficient. The next chapter will discuss these lessons, where conclusions on actor responsibility, legislation, and system deficiencies are formulated.

4. Discussion

4.1 Introduction

The PFAS contamination in Ronneby municipal drinking water was the starting point for taking action against PFAS. The study shows limitations in society's ability to handle persistent and complex chemicals. Despite existing documentation of known health and environmental risks linked with PFAS substances, actors failed to take action in time. This delayed action illustrates a gap in accountability and coordination. This study aims to evaluate which actors were responsible for the contamination, how they acted or did not act, and what weaknesses the system had that made long-lasting exposure possible. The study also aims to identify lessons contributing to stronger protection against future chemicals.

4.2 Why did the protection fail? Systemic failure and institutional fragmentation of responsibility

One of the study's central questions is why the authorities/actors in control fail to protect the public from contaminated drinking water despite legislation and knowledge about PFAS in general. The explanation could lie in a combination of unclear mandates, fragmented responsibilities, insufficient communication, and inadequate chemical regulations. Nevertheless, despite national and international knowledge about risks connected with PFAS, no actor took decisive or preventive actions before the discovery in Ronneby in 2013.

The precautionary principle under Chapter 2, Paragraph 2, and the self-monitoring requirements under Chapter 26, Paragraph 19 of the Swedish Environmental Code in connection with supervisory inspections (SFS 1998:808, 1998) they were not applied in practice by the Swedish Armed Forces. But also, the EU's regulatory framework under REACH was initially ineffective for handling PFAS substances, because of REACH's regulation methods of substance-by-substance assessment rather than PFAS as a group (Bock & Laird, 2022). The actors in this study operated in silos - failed to communicate (Tett, 2016) bound by limited mandates (Kemikalieinspektionen, 2025a), outdated guidelines (Bock & Laird, 2022), and neglected responsibilities towards the community and their residents, leading to thousands of residents being exposed to extremely high levels of pfas (Ronneby Kommun, 2024a).

4.3 Institutional blindness and missed signals

The case in Ronneby can be characterized by the terms institutional blindness and institutional ignorance, where risks were not acted upon because of structural limitations (Boullier & Henry, 2022; Paul et al., 2022). For many years, no risk assessment was carried out by the water utility Miljö & Teknik AB, and there were no requirements from the municipality to make one. In 2012, a risk inventory assessment was finally made, but the fire training site was not identified as a hazard. However, Enander (2016) states that due to limited or no knowledge about contamination of the groundwater from the fire training site, the possibility of discovering the contamination earlier would still be highly unlikely. However, the municipality and Miljö&Teknik AB should have questioned what activities are near the water protection area (fire training site) and what harmful chemicals might be present, and based on that, assessed what water samples to take. The design of protection regulations for a water protection area is preceded by an inventory aiming to identify existing and potential pollution sources and risk objects within the catchment area, with the goal of ensuring long term protection of the water source (Naturvårdsverket, 2010). Similarly, the Swedish Armed Forces continued to use firefighting foam containing PFAS despite internal and international warnings of its toxicity and persistence (Kaliber P1, 2019)

The ineffective transfer of knowledge between different actors is another example of institutional blindness. Agencies such as the Swedish Chemical Agency and the Environmental Protection Agency had knowledge and awareness about PFAS-related risks, but the information was not transferred to local actors (Kaliber P1, 2019). Meanwhile, the REACH system proved to be inadequate, due to the focus on individual substances such as PFOS and PFOA, while other PFAS substances were used without restrictions, which delayed restrictions on PFAS as a chemical group (Bock & Laird, 2022).

4.4 Failure to comply with legislation

The Swedish Armed Forces played a vital role in the PFAS contamination in Ronneby. They clearly failed to act upon Chapter 26, Paragraph 19 of the Environmental Code explicitly stating that operators shall "plan and control their activities to counteract or prevent damage to human health or the environment" (SFS 1998:808, 1998). There was no risk assessment, environmental controls, or groundwater sampling carried out despite decades of firefighting foam usage (Kaliber P1, 2019).

High values of PFAS were identified at F14 in Halmstad in 2009 by the Swedish Forced Army. This indication of environmental and health was not applied to preventive measures in Ronneby (Naturskyddsföreningen, 2022). Instead, they relied on inadequate safety data sheets that failed to include information about long-term health risks and environmental impacts, and continued to use PFAS-based firefighting foam with no regard for preventing environmental and health hazards (Kaliber P1, 2019). Kaliber P1 (2019) mentions the 2004 safety data sheet for firefighting foam stated that it was biodegradable, but also specified that environmental protection measures should be taken during exercises to avoid spreading to surface water, groundwater systems, and soil. Because of the documentation of the contamination in Halmstad, it is reasonable to assume that the Swedish Armed Forces knew the risk of further dispersion of PFAS. Therefore, according to SFS 1998:808 (1998), Chapter 26, Paragraph 19, they should have directly investigated potential spread at other military training sites, e.g., Tullinge and Kallinge. The failure to act on this knowledge raises serious concerns about whether they are following environmental regulations and whether their internal checks are sufficient.

Looking back, companies such as 3M and Du Pont already knew these risks, so the safety data sheets should have had correct classification much earlier, which might have made a difference in taking the right precautions for the Swedish Armed Forces.

This directly contradicts the precautionary principle of the Environmental Code. The precautionary principle (Chapter 2, Paragraph 3) is disregarded by ignoring or failing to recognize known risks despite there being warning signs. This contradicts their obligation to act cautiously and should have stopped using PFAS foam to protect the environment and human health. The Swedish Armed Forces should have questioned the effects and composition of the chemicals and been more updated when the information about PFAS effects already existed, and act with greater caution during exercises than they did. Their actions show the need for independent oversight even if they are a government activity. The Swedish Armed Forces conduct their own supervision (Försvarsmakten, 2023), by Chapter 26, Chapter 19 of the Environmental Code. They are therefore responsible for controlling that they are following the environmental legislation themselves. This can be problematic as self-monitoring can lead to conflicts of interest, which may affect the accuracy and integrity of the supervision. It could also make it more difficult to detect systematic flaws. Therefore, independent external oversight would be better to ensure that environmental requirements are met correctly.

At the national level, legal instruments were available that, if fully implemented, could have reduced the extent of the damage. The Environmental Code's precautionary measures (Chapters 2, Paragraphs 2–3, and Chapter 26, Paragraph 19, (SFS 1998:808, 1998), already included requirements for precautionary actions, self-monitoring, and risk assessments before 2013. Despite this, neither Ronneby Miljö & Teknik AB nor the Swedish Armed Forces took sufficient action to identify and prevent the risks associated with PFAS use (Försvarsmakten & Miljöprövningsenheten, 2016; Ronneby kommun, 2024b).

The Swedish Food Agency's regulations on drinking water (SLVFS 2001:30) formed the basis for control programs. However, because these regulations did not cover PFAS until after 2013, and since the Swedish Food Act (2006:804) did not explicitly regulate new chemicals of this type, the control systems were unable to detect the threat (Livsmedelsverket, 2001).

This difference between legal authority and actual implementation illustrates what Hill and Hupe (2002), refer to as an implementation gap between the intended design of policy and its actual execution. One contributing factor for this was the water providers only following their usual routines, checking national guidelines. This overreliance on checklists discouraged proactive investigation of site-specific risks, despite clear indications, just like the fire training site located within the water protection area (Ronneby kommun, 2024b).

The regulatory framework for drinking water also showed limitations. The 1998 Drinking Water Directive (98/83/EC) required drinking water to be clean and healthy (Union, 1998). Requirements for monitoring persistent organic pollutants such as PFAS did not exist even though their environmental risks were gradually becoming better known. This meant there was no specific legal requirement to detect or address PFAS in drinking water when the contamination in Ronneby developed. Today, by the revision of the Drinking Water Directive in 2020 (Direktiv 2020/2184, 2020) requirements for the control and limitation of PFAS in drinking water exist. This reflects a growing understanding of the risks associated with these substances, as well as how slow the legislation process is to adapt to new environmental challenges.

4.5 Systematic repetition of past mistakes

A recurring theme in this study is how knowledge about PFAS existed on different levels in society from manufacturers, authorities, and scientists. However, this information did not reach actors effectively to make any precautionary measures. This illustrates the need for institutionalized channels for knowledge transfer from expert authorities to municipal operations. For Ronneby it meant that the municipality did not receive the information they needed in time to prevent further damage, even though information was out there.

International and national knowledge about PFAS risks existed long before the discovery of PFAS in Ronneby's drinking water in 2013. 3M and DuPont knew for decades about PFASs toxicity and persistence but had this information withheld from the public eye. The podcast Dark Waters uncovered memos describing discussions about how to spin the negative effects of PFAS into a positive story (Rosengren et al., 2024), an unsettling example of capitalism at work. Kaliber P1 (2019) stated in their investigation that the Swedish Chemicals Agency had already been warned about PFOS in 2004. In Sweden, indications of PFAS contamination in groundwater were found as early as 2009 in Halmstad and 2011 in Uppsala (Naturskyddsföreningen, 2022).

The Swedish Chemicals Agency issued a report in 2004 proposing that PFOS and similar substances should be phased out (Kemikalieinspektionen, 2004). The EU banned PFOS and its sales in 2007. However, firefighting foam was still allowed to be used until 2011 (Kaliber P1, 2019). So, despite the ban on PFOS, and earlier cases in Sweden showing PFAS contamination connected to fire training sites by the military, it still did not lead to preventive measures such as systematic testing of drinking water. In 2008, water samples of the groundwater were taken by consultants on behalf of the supervisory authority within the Swedish Armed Forces near the fire training site at F14 Halmstad. Elevated levels of PFAS were discovered, and the municipally were contacted.

The reports mentioned that environmental and health risks should be investigated. Despite this discovery it did not lead to the Swedish Armed Forces immediately initiating an investigation of the groundwater at other fire training sites in Sweden. No immediate actions were taken by municipalities either. The fact that there was no water sampling for PFAS, after these earlier warnings highlights institutional inertia.

Aksom (2022), defines institutional inertia as "a long-lasting exposure of institutional effects encoded in taken-for-granted (institutionalized) routines on organizational trajectory changes." Meaning that well-established methods and practices within an organization can have difficulty adapting to change. For authorities in Ronneby before systematic PFAS testing, the existing routines for water monitoring, which did not include PFAS, can be understood as this type of institutional inertia. This made it likely harder for the organization to consider or adopt new practices, like testing for unknown substances such as PFAS, because it went against their usual work methods.

The tendency to overlook scientific warnings and delay regulatory actions is not unique to PFAS. Historical cases with other persistent environmental toxins, such as DDT and PCB, showed similar developments. Known risks with PCB existed since 1930 and the first well known warning came in 1968 with 1800 poisoned by contaminated rice (Harremoës et al., 2001). Research on DDT showed harmful effects on birds, which got wide attention through Rachel Carsons book Silent Spring. Despite early warning signs, a ban in Swedish agriculture was delayed until 1970, and a complete ban did not occur until 1975 (Sveriges lantbruksuniversitet, 2022).

The parallels between Ronneby, other PFAS cases (Halmstad, Tullinge/Uppsala, USA, and Australia from this paper), and the example of other chemicals with similar traits like DDT and PCB are apparent. In all of these cases, early knowledge about the risks, from industry, research, or incidents, was not quickly translated into sufficient preventive or regulatory measures. The repetition of these mistakes can be traced back to the systemic issues highlighted by the Ronneby case.

4.6 What should have been done, improvements and the future

The Swedish Armed Forces should have conducted risk assessments, conducted water sampling, and been educated on the environmental risks associated with handling PFAS foam. They had a responsibility to understand the consequences of their actions in handling harmful chemicals. A thought to reflect on is that it is not enough to solely rely on laws and guidelines; it should also be about proactively identifying and managing risks for humans and the environment. Regularly conducting risk assessments and educating could be a way of creating sustainability and awareness against potential new threats. The contamination could have been reduced by proper guidelines for handling environmentally hazardous substances and by having their employees updated and educated. Which leads to the question: Was the absence of action mainly due to ignorance or lack of prioritization?

The supervision, by (Generalläkaren) of the firefighting exercise facilities, should have been much more substantial. One cannot rule out that the insufficient supervision could have been due to the fact that it is difficult to supervise its own organization. The reason for not letting the County Administration Board handle the supervision is, of course, the secrecy issue. However, that could probably be handled by letting one unit at a County Administration Board, somewhere in Sweden, take care of all military activities. The staff in this unit, could them be classified by SÄPO, and they could sign Confidential Agreements.

Ronneby municipality and its utility company Miljö&Teknik should have done broader risk assessments with an open mind. They should also have realized that the fire training site could be a possible threat. If they had followed up on that lead, an investigation into PFAS in drinking water could have been initiated earlier. This highlights that they should not only rely on known hazards but actively assess potential environmental threats in the area. The government and parliament should consider the option of making regular, recurring risk assessments of all municipal water sources mandatory.

Ronneby Miljö & Teknik AB should have made tougher requirements for their own water control, even if PFAS was not included in the Swedish Food Agency's recommended analysis list. Those responsible for the drinking water supply should act proactively, especially when international research had identified PFAS as a potential health risk early. This raises the question of a possible system failure, where responsible actors tend to wait for clear government directives before taking action, despite the precautionary principle under the Environmental Code requiring preventive measures even when a risk is suspected.

The Swedish Chemicals Agency and the Swedish Environmental Protection Agency had knowledge, but did not have efficient strategies for communicating risks to municipal actors. This highlights a larger shortcoming in Sweden's management of environmental toxins, that is, the inability to communicate complex but important risks in a way that creates understanding and leads to action. Knowledge alone is not enough; it must be translated into action.

Since the discovery of extremely high levels of PFAS in drinking water in Ronneby in 2013, numerous significant actions have been implemented. At the European Union level, the REACH framework is shifting from regulating substances individually to implementing class-based restrictions on PFAS, with the goal of proactively preventing future harm (Bock & Laird, 2022). There is ongoing work from REACH on restricting PFAS substances (European Chemicals Agency, 2024a), however the processes are very slow probably due to factors such as complex substance, international cooperation is needed with bureaucratic work. Not to mention the economic and industrial parts, where businesses might be restricted due to profit loss. With that said, by the end of 2025, 3M promises to stop producing any PFAS (Baker, 2025).

In Sweden, there are new threshold values for PFAS in drinking water. Livsmedelsverket (2025), has published the limit values. For PFAS 4 (PFOA, PFNA, PFOS, and PFHxS), it is 4 ng/l, and for PFAS 21, covering PFAS 4 and additional PFAS substances, it is 100 ng/l. The PFAS limit values will take effect on January 1, 2026. Since 2013, new national PFAS networks such as SamTox have been established to prevent and manage chemical risks in society (Kemikalieinspektionen, 2020). The PFAS network is also where government representatives, researchers, county administrative boards, municipalities, consultants, and companies can exchange knowledge. It also aims to address the issues around PFAS, which is to find solutions and prevent future problems (Kemikalieinspektionen, 2023b).

The Swedish Environmental Protection Agency could be more proactive and initiate monitoring of all manmade very persistent substances that are used in relatively large amounts, in order to have a potential to discover future similar problems before severe health or ecological problems occur. The government could give the Swedish Chemical Agency, Swedish Agency for Marine and Water Management, and the Swedish Environmental Protection Agency clearer instructions about bringing knowledge about international incidents, similar to the PFAS story in Ronneby, Sweden, and ensuring that all concerned actors are informed.

5. Conclusions

The PFAS contamination in Ronneby is a clear example of a systematic failure to address the long-term risks of persistent and bioaccumulative chemicals. Although there was already extensive international knowledge about the risks of PFAS compounds long before the discovery of the contamination in 2013, this knowledge was not effectively translated into preventive measures or sufficient national regulations promptly. Early indications of PFAS contamination in Sweden occurred in Halmstad (2009), Tullinge (2011), and Uppsala (2012) without measurements taken, highlighting the institutional inertia characterized by the growing problem with PFAS. Actors failed to work actively to prevent harming the environment and human health. Unfortunately, the Swedish Armed Forces, responsible for the pollution in Ronneby, was unsuccessful in applying the requirements for segments in chapters 2,10, and 26 in the Environmental Code, and Miljö & Teknik AB/municipality, responsible for the drinking water failed to identify the fire training site in Blekinge as risk area and relied on guidelines from the Swedish National Food Agency, with no guidelines on PFAS existing yet. Simultaneously, there was a fragmented chemical regulation at the EU level, particularly within REACH and the Drinking Water Directive, which was too slow and unclear, delaying measures that could have prevented or mitigated the pollution.

Limiting the pollution in Ronneby would have been possible because the contamination came from a point source. It is easier to detect and manage pollution when it originates from a single, identifiable source, rather than from diffuse sources that are spread out over a larger area. The difficulty may have been that PFAS is a massive group with several thousand different compounds, combined with effects including cancer and reproductive disorders, which are relatively difficult to determine.

A risk inventory around the water source is crucial, since it is almost impossible to test all possible hazardous substances, a well accomplished, open ended risk assessment would have lead efforts toward the specific PFOS/PFAS substances. The Swedish Armed Forces should have looked into how the substances they used in large amounts could have dispersed, especially since it was clear they could contaminate the soil.

The Ronneby contamination ultimately showed fundamental systemic error, with insufficient communication, uncertain mandates, and fragmented responsibilities. These factors ultimately hindered effective action and created a situation where warning signals were missed. Even though laws and regulations regarding chemicals and pollution existed, their application was insufficient.

History repeats itself. Recurring patterns of missed warning signals and delayed responses have also been observed in previous cases with environmental toxins (DDT and PCBs), highlighting the need to learn from past mistakes and implement improved systems för managing new chemicals.

To prevent similar incidents from happening, it is necessary to increase preventive awareness and communication around new chemicals among relevant actors. Improved and faster chemical regulations are also necessary. Stronger compliance measures and better supervision of fundamental environmental legislation, especially Parts 2 and 26 of the environmental code, are also needed.

The Swedish Armed Forces should also have looked into how the substances, which were used in large amounts, might have spread, since the risk of soil contamination was clear. Ultimately, one key takeaway is that doing the fundamental, “simple” things is important. If you are going to distribute drinking water, you must investigate to ensure that there are no potentially polluting activities nearby. If there are, they need to be investigated carefully! If large amounts of chemicals are spreading to surrounding land as a result of your operation, these effects need to be thoroughly investigated.
If you supervise an activity that spreads chemicals to the surrounding area, act! If you receive new and important information, spread it immediately to everyone who might be affected!

In conclusion, the Ronneby case finally shows the alarming general vulnerability in dealing with persistent chemicals. Furthermore, it is not just within Sweden, there are institutional and regulatory barriers everywhere. It is an important example for protecting the environment and human health from future chemical threats. Lastly, monitoring programs at a national level should include all highly persistent substances that are used above a certain amount annually, even if their toxicity is unknown.

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