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Contamination analysis of the landfill Rösaberg inerta massor

Risk assessment and investigation of the contaminant distribution

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Lisa Westander

ABSTRACT

Contamination analysis of the landfill *Rösaberg inerta massor*

-risk assessment and investigation of the contaminant distribution

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The dispersion of contaminants deriving from landfills poses a risk to the surrounding environment and human health. Old landfills are treated with extra precaution, due to their poorer construction, less stringent operation and lack information regarding the waste content. Vetlanda municipality has identified 48 old landfills. One of them is *Rösaberg inerta massor*. It is one of the largest landfills in the region and is located close to numerous sensitive environmental receptors (such as the river Emån). During a phase 1 investigation (MIFO 1) in 2017, the landfill was designated the highest risk classification, class 1, and is considered a very high risk to environment and human health. No sampling was conducted during this time, but the level of contaminants was assumed to be very high.

The objective of this study was to investigate the prevalence of contaminants by determining the pollution levels in soil and groundwater in the landfill. Samples was obtained by completing a site investigation, involving trial pits examination and installing of monitoring wells. National as well as site-specific guideline values were used to determine the effects of the contaminant levels of the site. In the software Groundwater Modeling system (GMS) was used to study if the contaminant plumes reach the river Emån. A 50-year scenario was set up in GMS to investigate likely concentrations in the future. Finally, a new risk assessment of the site was done, based on the obtained results.

The results indicated that the landfill does not pose such a large environmental risk that initially was expected in the phase 1 investigation. The level of contaminants was higher in the groundwater than in the soil. High concentrations of PAH-Hs and 2,6-dichlorobenzamide were found in two of the groundwater samples. However, the risk assessment using the information obtained from the study indicated a lower risk than what was estimated in the MIFO 1 assessment 2017. In this study, the risk of the landfills current properties was evaluated to a risk 2. The 50-year scenario indicated that contaminants in the uppermost groundwater layer will have dispersed in a higher rate than the contaminants in the lower layer. The risk was estimated to a risk 3 in 50 years. It should be noted that no samples was conducted in river Emån which needs to be done before ruling out the necessity for remediating the groundwater. No remediation action for the soil was assessed to be necessary.

Keywords: Landfill, MODFLOW, Risk assessment, Site-specific guidelines

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REFERAT

Föroreningsanalys av deponin *Rösaberg inerta massor*
-undersökning av riskklassning och föroreningsspridning

Lisa Westander

Spridning av föroreningar som härrör från deponier riskerar att påverka den omgivande miljön och människors hälsa negativt. Framför allt gamla, nedlagda deponier bör behandlas med extra försiktighet då de ofta ackompanjeras av otillräckliga sluttäckningskonstruktioner och bristande kunskap om deponins innehåll och utbredning. Det finns i nuläget 48 kända nedlagda deponier i Vetlanda kommun, där en av dem är *Rösaberg inerta massor*. Den är bland de största deponierna i området och ligger nära ett flertal skyddsvärda objekt i området, såsom Emån. Under en MIFO 1-undersökning som utfördes 2017, ansågs deponin uppnå den högsta riskklassningen (riskklass 1) som innebär att området betraktas som en mycket hög risk för människors hälsa och omkringliggande natur. Inga prover genomfördes under denna undersökning, men föroreningsnivån antogs vara hög då liknande deponier i närheten uppvisat höga föroreningshalter.

Syftet med denna studie var att undersöka förekomsten av föroreningar och dess halter i området för att kunna dra slutsatser om deponins effekter på närliggande miljö och människor. Data för föroreningsförekomst och halter i mark och grundvatten erhölls genom att genomföra en platsundersökning där provgropar grävdes samt grundvattenrör installerades. För att kunna uppskatta effekterna som föroreningsnivåerna skulle ha på platsen togs generella såväl som platsspecifika riktvärden fram och jämfördes med de uppmätta halterna. För att kunna fastställa vilken risk som deponin utgör för Emån studerades föroreningsplymernas flödesmönster i grundvattnet i datorprogramvaran GMS. Spridningsgraden och den sannolika föroreningshalten i framtiden undersöktes genom att inrätta ett 50-årigt scenario i GMS. Slutligen gjordes en ny riskbedömning av området baserat på de erhållna resultaten.

Resultaten visade att deponin inte innehåller de höga föroreningshalter som initialt befarades. Generellt visade sig föroreningsnivåerna vara högre i grundvattnet än i marken. En riskbedömning genomfördes med hjälp av resultaten erhållen från studien och gav indikationer på en lägre risk än den ursprungliga klassningen. Klassningen resulterade i en riskklass 2 med strikt bedömning då några föroreningar stack ut från den generellt annars låga föroreningshalten, såsom PAH-H:er samt pesticiden 2,6-diklorbensamid i grundvatten. Scenariot för föroreningssituationen i ett 50-årsperspektiv visade att föroreningar från det övre grundvattenlagret sprids och minskar mer i halt än det undre skiktet. Riskklassningen för detta scenariot uppskattades till en riskklass 3. Det bedömdes att en åtgärd inte är nödvändig för mark på grund av dess låga föroreningshalt. För grundvatten rekommenderas vidare undersökningar på Emåns påverkan av föroreningar från deponin innan en avskrivning av åtgärder kan göras.

Nyckelord: Deponi, MODFLOW, Riskbedömning, Platsspecifika riktvärden

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PREFACE

This master thesis comprises 30 credits and is finalizing the Master´s Programme in Environmental and Water Engineering at Uppsala University and the Swedish University of Agricultural Sciences. The project was conducted in conjunction with AFRY, where Henrik Kempengren was supervising the project. Subject reader was Dan Berggren Kleja, Department of Soil and Environment, Swedish University of Agricultural Sciences. Examiner was Monica Mårtensson, Department of Earth Sciences at Uppsala University.

I would like to thank Henrik for the consistent support and help throughout the project, especially in the planning leading up to the field investigation. Thanks to Dan Berggren Kleja, for the useful feedback and inputs regarding my work. I would also like to thank Thomas Svensson, Vetlanda municipality, and Robert Gass, Njudung Energi for your valuable thoughts during the field investigation, sponsoring of the excavator, for your help in collecting groundwater samples and for your everlasting enthusiasm. Thanks to Eurofins for your sponsoring of laboratory analyses and for your interesting inputs and help regarding choice of analyses. Finally, I would like to say a special thanks to AFRY for financing the project and to the team at Contaminated Areas South in the Malmö office for your welcoming and helpful approach.

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POPULÄRVETENSKAPLIG SAMMANFATTNING

Deponier, eller soptippar som det kallas i vardagligt bruk, var ett vanligt sätt att göra sig av med avfall i Sverige under 1900-talet. När de anlades visste man inte hur avfall kunde återanvändas eller återvinnas och därför lades soporna i hög i hopp om att de skulle brytas ner naturligt. Inte heller fanns några strikta lagar hur soporna skulle hanteras på deponin eller hur naturen och människor kunde påverkas negativt av de föroreningar som började spridas från soporna. 2001 infördes nya lagar i en förordning som beskrev hur deponier ska underhållas för att undvika för höga risker på människor och natur i närheten. Dessa lagar och regler kontrollerade vad som fick läggas på deponierna och framförallt hur deponierna skulle konstrueras för att undvika spridning av föroreningar. För deponier som lades ner innan denna förordning trädde i kraft, gäller inte dessa regler. Risken är därför stor att gamla deponier orsakar en hög belastning på miljön och de människor som vistas i närheten.

I Vetlanda kommun finns det 48 kända nedlagda deponier. Kommunen jobbar här med att undersöka vilken fara varje deponi utgör. På så sätt kan de deponier som medför högst risker på människor och natur prioriteras åtgärdas först. För deponin *Rösaberg inerta massor* har en orienterande undersökning (MIFO 1) gjorts, där risken som den antas ha på omgivningen togs fram. Riskklassningen resulterade då i riskklass 1, vilket innebär mycket stor risk. I denna undersökning togs inga föroreningsmätningar, men eftersom flera andra deponier i området hade visat på höga föroreningshalter, antogs att det även var höga värden i *Rösaberg inerta massor*. Deponin ligger nära Emån, som mynnar ut i Östersjön och har utsetts som en vattentäkt som är extra viktig att skydda. Dessutom ligger andra typer av naturområden som anses vara speciella att bevara. Att *Rösaberg inerta massor* potentiellt har höga föroreningar som sprids till dessa platser är därför något som absolut vill undvikas.

Examensarbetets syfte var att undersöka föroreningssituationen i deponin. Genom att bekräfta vilka föroreningar som finns i området, och i vilka halter, kunde en bedömning göras om riskklassningen som sattes under MIFO 1-undersökningen stämde. Detta gjordes genom att först undersöka deponin på plats under en fältundersökning.

När resultaten kom tillbaka från laboratorieanalysen jämfördes data med de riktlinjer som pekar på hur stor risk just denna halt indikerar. För att anpassa riktlinjerna för att passa just området kring Rösaberg inerta massor togs platsspecifika riktvärden fram. I datorprogramvaran GMS undersöktes hur grundvattnet borde röra sig i området och hur föroreningarna i grundvattnet sprider sig. I programmet togs även föroreningshalten fram för hur den bör se ut om 50 år.Med de nya resultaten kunde en ny riskklassningsundersökning göras.

Resultaten visade att föroreningssituationen inte var så utbredd som befarades under MIFO 1-undersökningen. Det var färre föroreningar som överskred de jämförda riktvärdena i jorden än vad som gjordes i grundvattnet. Riskbedömningen som sammanfattade de erhållna resultaten från de olika delarna av examensarbetet resulterade i en riskklass 2. Scenariot för föroreningssituationen i ett 50-årsperspektiv visade att föroreningar i det övre grundvattenlagret sprids och minskar i en snabbare hastighet än de i det undre skiktet. Riskklassningen för detta scenariot uppskattades till riskklass 3. Inga åtgärder bedömdes nödvändiga för marken, men en framtida undersökning rekommenderas på Emån för att säkerställa att grundvattnet inte påverkar Emån negativt.

WORDLIST

BTEX	Benzene, toluene, ethylbenzene and xylenes
Contaminant plume	Groundwater containing contaminants spread from a source
DOC	Dissolved organic matter
Hydraulic conductivity	Describes how easily a liquid can be transported through soil
Leachate	Liquid that has passed waste and is now contaminated
Inert	Material not considered hazardous
GIS	Geographic Informations System.
GMS	Groundwater Modeling System
KM	Sensitive land use
k_d-values	Describes the mobility of a substrate
MIFO	Method of Surveying Contaminated Sites
MKM	Less sensitive land use
MODFLOW	Program in GMS to simulate hydrologic environments
MODPATH	Program in GMS to simulate particle flows
MT3DMG	Program in GMS to simulate contaminant plumes
PAH	Polycyclic aromatic hydrocarbons
PCB	Polychlorinated biphenyls

TABLE OF CONENT

1 INTRODUCTION

A landfill is a site in or on top of the ground where waste is disposed and stored (Statens geotekniska institut 2018). Due to the many negative effects that a landfill may cause its surroundings by leachate, pollution of groundwater and emissions of greenhouse gases, the waste management method is today ranked as the least preferable according to EUs waste management hierarchy (European Commission 2019a). Nevertheless, it is historically, and still is today, the most commonly used waste management method across the world due to its simplicity. Even if Sweden is one of the leading countries in waste management with recycling as the main management tools (Sopor.nu 2020), that has not always been the case. Before the 1990s, Swedish waste was handled in a linear way, where all waste was landfilled or incinerated, with little or no regulations (VafabMiljö 2018).

It was not until 2001 when the landfill regulation (2001:512) became effective that the numbers of active landfills started to decrease significantly. This regulation covers all landfills that have been active after 16 July 2001 and entails strict requirements regarding leachate, waste materials allowed, precautionary measures around and in the landfill as well as its final cover. Landfills that closed before 16 July 2001 however, are not subject to the regulation and are merely considered as a contaminated site. Consequently, most of the old landfills do not meet the same environmental and safety standards as the new ones, and often the information of their content is limited. Consequently, the old and closed landfills are considered ongoing hazardous operations as they may imply a high risk on their surroundings. Because of this, the Swedish government aims to identify, map out, and remediate the old, high-risk landfills in order to meet the Swedish environmental goals (Rihm 2014).

Vetlanda municipality has identified 48 known old landfills. Many of them lack bottom sealing and final coverage. This means that contaminants have a higher possibility spread to the surrounding environment. Thus, the municipality is working on an action program aimed to handle these landfills. A numerous of landfills have already been investigated. These showed a broad range of characteristic contaminants originating from household waste such as PAHs, heavy metals, PCBs and chlorinated solvents. The risk was therefore assessed to be very large for many of the landfills *(*ÅF 2017).

One of the closed landfills, that is not regulated under the landfill regulations, is *Rösaberg inerta massor*. It is one of the largest landfills in the region, with an area of 33 900 m^2 and an estimated volume of 191 800 m^3 (Svensson n.d. in ÅF 2017). Due to its proximity to a numerous of protected objects in the area such as river Emån, remediation is important if assessed necessary. During the orientation study MIFO 1 in 2017, the landfill was given the highest risk classification: risk 1. No samples were conducted during this time, but the level of contaminants was assumed to be very high (ÅF 2017).

1.1 OBJECTIVES

The objective of this study was to investigate the prevalence of contaminants. Second, to determine the risk that the landfill may pose on the adjacent environment and to human health as well as its need of remediation.

1.2 RESEARCH QUESTIONS

1.2.1 Main research questions

1. What will a new generic risk assessment for the landfill result in and how will this change in 50 years?
2. What recommended remedial actions does a site-specific risk assessment result in?

1.2.2 Sub-questions to answer the main research questions

1. What contaminants are found in the landfill and in what concentrations?
2. What are the flow patterns of the contaminant plumes in the groundwater in the eastern apart of the landfill?
3. What is the estimated level of groundwater contaminant in the eastern part of the landfill in a 50-year scenario?

2 THEORY

2.1 HETEROGENEITY OF LANDFILLS

The composition of a landfill is often spatially varied and heterogeneous, since the deposit of waste normally occurs in different stages and with a variation of waste material. Therefore, it is likely that the materials particle size, water content and contamination levels vary across the landfill area. For this reason, different processes, such as leachate, rate of degradation and emissions of landfill gases, occur at different times and rates in the landfill (Rihm 2011). Due to this, it is difficult to conduct a sample methodology that will mirror the entire contaminant situation of the landfill (Rihm 2014).

2.2 LEACHATE

Leachate is water that has infiltrated the landfill and has been in contact with the potentially contaminated waste materials. The water primarily originates from precipitation that has infiltrated the top of the landfill and slowly passes through the masses. For old landfills, leachate sometimes also originate from groundwater and runoff water due of the often inefficient cover constructions. The leachate is eventually pressed out from the landfill due to compaction. The risk is therefore high that the leachate contaminates the adjacent environment and groundwater. How much leachate that a landfill can produce depends on the landfill's quality, size and age, as well as the inflow rate, temperature, degradation phase of the landfill material, location and the topography (Naturvårdsverket 2008).

2.3 WATER FLOW PROPERTIES IN SOILS

A soil section is divided into the unsaturated zone, which is located on top of the saturated, groundwater zone. The potential for leachate to flow through the soil depends on several physical, biological and chemical factors (Grip and Rohde 1994).

2.3.1 Soil-water potential

Gradients in the *total soil water potential* indicate which direction water will flow: waters in regions of high total soil water potential will flow to lower. In practice, this means that the water flow will be directed vertically and in a slow rate in the unsaturated zone. In the saturated zone, the direction of the groundwater flow will be predominantly horizontal with a velocity that can be described with Darcy's law (*Equation 1*) (Grip and Rohde 1994).

$$Q = -K \cdot A \frac{d\Phi}{dx} \tag{1}$$

where

Q = Discharge [m^3/s]

A = cross-sectional area for the soil [m^2]

K = hydraulic conductivity of the soil [m/s]

$\frac{d\Phi}{dx}$ = potential gradient [m/m]

2.3.2 Hydraulic conductivity

Hydraulic conductivity (*K*) describes how easily water can be transported through a soil material. *K* depends on the saturation rate, pore size and how the pores are distributed in the soil. The more saturated the soil is and the larger the pores are, and the larger the *K* and the easier it is for the water to flow. For example, a coarse sand material will have a higher conductivity than a fine-grained clay material (Grip and Rohde 1994). Also, a high confinement pressure decreases the hydraulic conductivity, meaning that a higher depth will decrease *K* (Reddy et al. 2009).

2.3.3 Water holding capacity

The soils capacity to hold water depends on processes of adsorption and surface tension. Soils containing small, fine particles have stronger adsorption potential than larger particles since small particles have a larger particle surface porportion per volume soil. The water holding capacity also depends on the tension that occurs on the water surface in the unsaturated zone. Water in heterogeneous soils and coarse soil will more easily be drained than in homogeneous soils or soils with fine particles. The holding capacity is heavily dependent on what pressure the soil is exposed to. At potentials with no pressure (close to zero), the soil is almost fully saturated. The higher the pressure becomes; more water is drained from the soil (Grip and Rohde 1994).

Soils with a low hydraulic conductivity and a large water holding capacity have a long residence time for the soil water. If this water is contaminated, the risk of contaminant dispersion will be low but may lead to an accumulation of contaminant concentration in the groundwater at that specific location (Kempengren 2017).

2.4 TRANSPORT OF CONTAMINANTS IN SOILS

When a contaminant is dissolved and infiltrates the groundwater, it will be transported in different ways. The velocity of this mass transport depends on two things: in what way it is being transported in the water, and how easily the substrate is sorbed along the way (Berggren Kleja et al. 2008).

2.4.1 Ways of transportation

The most dominant way of mass transfer is by *advection:* when the substance follows the groundwater flow. Its pace depends on which route the different water molecules take in the pore system, which causes a *dispersion* of the contaminant in the soil. *Diffusion* is transportation of substances caused by gradients in its concentration rate. This way of transporting is common in landfills, where contaminants in the waste diffuse into the leachate. Next, the leachate finds its way out from the landfill by infiltrating the bottom or the top cover/cap of the landfill, again by diffusion. An essential factor for diffusion to occur is the water content of the material. The lesser water in the system, the lesser diffusion (Berggren Kleja et al. 2008).

2.4.2 Retention processes

How much of the dissolved substances in the groundwater that are being taken up (adsorbed) by microorganisms, roots or soil particles depends on the type of substance (heavy metals are generally strongly sorbed for instance) concentration of the substance, acidity and the redox potential. Retention is an influential factor regarding how fast and far the transportation of a contaminant will be able to spread (Berggren Kleja et al. 2008).

2.4.3 Colloids and DOC

Colloids are microscopic particles suspended throughout the water with no, or very slow sedimentation (Nationalencyklopedin n.d.c). The particles are often made of carbon or clay but can also be formed by precipitation of metal hydroxides or oxides, which can happen in landfills when reduced leachate reach oxygen rich water bodies (Berggren Kleja et al. 2008). The contaminants bind to the colloid, which in turn is transported with the flowing water. That means that the contaminant can travel very far from its starting point. Generally, contaminants with a low solubility have a higher affinity to bind with colloids (Jonsson 2011). The dissolved form of organic matter, DOC, have a high mobility in water. DOC sorbs heavy metals strongly and hence, it increases the mobility of heavy metals in the groundwater (Berggren Kleja et al. 2008).

2.4.4 pH

The soil particles surface is slightly negatively charged. During normal pH-values, it will sorb metal cations. A smaller part of the soil particle's surface is positively charged and will bind to anions (Elert et al. 2006). When the pH in the soil decreases, the positively charged heavy metals will bind to the soil particles less strongly, because there will be more hydrogen ions around to compete with the soil particle's surface. Generally, during low pH-values, anions will have a stronger sorption to the soil particles. The reverse relation applies for high pH-values (Berggren Kleja et al. 2008).

2.4.5 Redox potential

During a redox reaction with two different substances, electrons will be transferred between the two. This will oxidize the electron giver and reduce the electron receiver. The redox potential describes the balance between the oxidizing and reducing substances (Branzén et al. 2013).

2.4.6 k_d-values

To identify the mobility of a substance, the k_d-values can be derived. k_d-values assumes a linear relationship between the concentration of the substance in the solid phase and the concentration in the liquid phase (*Equation 2*). This value is therefore an indication of how much of a dissolved contaminant in the groundwater that is being adsorbed (Elert et al. 2006).

$$k_d = \frac{Concentration\ in\ solid\ phase\ (mg/kg\ TS)}{Concentration\ in\ liquid\ phase\ (mg/l)} \qquad (2)$$

2.5 LIFE CYCLE OF A LANDFILL

The microbial degradation of organic dense materials in a landfill undergoes four decomposition phases. These stages have different characteristics in terms of emissions, redox potentials, leachate and pH. Due to the landfill's heterogeneity, these phases will occur at different times and pace across the landfill.

2.5.1 Aerobic phase

Oxygen is present in the pores of the waste material in the first degradation phase. Oxygen is used as electron acceptors during the microbial respiration and is consumed rapidly. Here, it is primarily simple organic compounds that is being degraded. The respiration results in a production of carbon dioxide (CO_2) and heat. The aerobic phase lasts there is no more oxygen left, which normally takes a few days (Kempengren 2017). Due to the lack of oxygen, other molecules must replace the electron acceptor title in the respiration, such as nitrate which produces nitrogen gas (N_2) (Naturvårdsverket 2008).

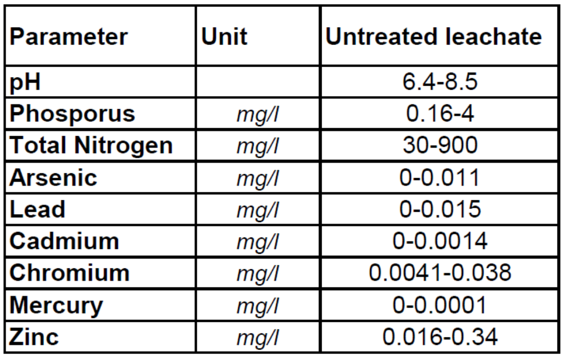
2.5.2 Anaerobic acid phase

The activated anaerobic bacteria decompose complex organic compounds in the waste into organic acids, such as alcohols, carbon dioxide and carboxylic acids by hydrolysis. These acids reduce the pH in the waste (Bozkurt, Moreno and Neretnieks 2000). As the waste become more acid, the characteristics of the waste changes: the solubility of many metals increases, such as zinc and iron. Consequently, the leachate from the landfill will contain high levels of these metals. The anaerobic acid phase lasts for approximately ten years (Naturvårdsverket 2008).

2.5.3 Methanogenic phase

Anaerobic bacteria, suitable for the anoxic conditions (strictly anaerobic) produce methane by degrading organic acids (Bozkurt, Moreno and Neretnieks 2000). Due to the high microbial activity, the pressure in the landfill is higher than the atmospheric pressure. The reaction increases the pH to reach about 8, which inhibits solubility of metals, and therefore the leachate of metals. It is expected to find a high level of nitrogen, iron and chlorides in the leachate however, as well as lead. A summary of the properties in a landfill undergoing the methanogenic phase can be found in *Table 1* (Naturvårdsverket 2008). This phase lasts about one hundred years and is therefore the phase that most of the old landfills is currently in (Bozkurt, Moreno and Neretnieks 2000).

***Table 1**: Summary of normally found levels of different parameters in methanogenic landfills (Naturvårdsverket 2008).*



Parameter	**Unit**	**Untreated leachate**
pH		6.4-8.5
Phosporus	*mg/l*	0.16-4
Total Nitrogen	*mg/l*	30-900
Arsenic	*mg/l*	0-0.011
Lead	*mg/l*	0-0.015
Cadmium	*mg/l*	0-0.0014
Chromium	*mg/l*	0.0041-0.038
Mercury	*mg/l*	0-0.0001
Zinc	*mg/l*	0.016-0.34

2.5.4 Humic phase

When the methane production slows down, the landfill has reached its last phase, the humic phase. Now, the only remaining organic material left in the substrate is high molecular compounds resistant to degradation (Naturvårdsverket 2008). Due to the low microbial activity, the gas pressure decreases, which allows oxygen to infiltrate the landfill again (Östman 2008). Redox conditions in the landfill will be determined by the rate of oxygen infiltration and the pH. There is therefore a risk for an increase of metal leachate during this phase. Research and information of this phase is sparse however, since few landfills have reached the humic phase yet (Bozkurt, Moreno and Neretnieks 2000).

2.6 SUSPECTED CONTAMINANTS

2.6.1 Aliphatic compounds

Aliphatics are organic compounds containing a chain of hydrogen and carbon atoms, such as hydrocarbons. The properties of aliphatic compounds depend on the numbers of atoms the chain includes and the number of bonds between each atom (Nationalencyklopedin n.d.a). Natural gas or mineral oil, such as methane, ethane, propane and butane, are aliphatic compounds with only one bond between its atoms (alkanes) (Stauffer, Dolan and Newman 2007). The compounds volatility depends on the length of its hydrocarbon chain. Aliphatics with a short chain (not more than 12 carbon atoms) are volatile and soluble in water and therefore have a great potential for dispersion. Consequently, these compounds risk to contaminate, and travel far with, groundwater and soil water. Compounds with longer chains have a higher viscosity (thick liquid). Due to this, these compounds are not as volatile or soluble and can therefore often be found close to the source of pollution (SGF - Åtgärdsportalen 2018a).

2.6.2 Aromatic compounds and BTEX

Aromatic hydrocarbons are shaped in a stabilized ring structure. The most fundamental structure is the benzene compound, with six carbon and hydrogen atoms (Stauffer, Dolan and Newman 2007). Aromatic hydrocarbons can either be monocyclic (MAH), which means the compound consists of one ring only, or polycyclic (PAH), which is compounds with multiple rings bonded together (Nationalencyklopedin n.d.b). MAH compounds can often be found in aliphatic dense products, such as in solvents and fuel products and therefore have the same dispersion potential as aliphatic compounds. Aromatics are however significantly more toxic than aliphatic hydrocarbons and have a strong odor (SGF - Åtgärdsportalen 2018e). BTEX stands for the aromatic compounds' benzene, toluene, ethylbenzene and xylenes. These are one of the most extensively produced chemicals in the world and can be found in oil products such as gasoline, diesel and heating oil. The BTEX compounds are more volatile and soluble in water than longer aromatics and is therefore easily dispersed, in soil, air as well as in waters (SGF - Åtgärdsportalen 2018b).

2.6.3 PAHs

Polycyclic aromatic hydrocarbons (PAH) are compounds made of multiple benzene rings fused together (Stauffer, Dolan and Newman 2007). PAH compounds are often toxic to living organisms and are released during incomplete combustion (Nationalencyklopedin n.d.f). The Swedish Environmental Protection Agency (EPA) have listed 16 PAH compounds that is considered toxic to humans, with 13 of them deemed cancerous (Naturvårdsverket 2009a). The aromatic hydrocarbons have been classified based on their molecular weight where PAH-L, PAH-M and PAH-H- represents a low, medium and high molecular weight. PAH-Ls have a high solubility and are therefore easily dispersed through groundwater. In contrast, long chained, PAH-H are less inclined disperse than short chained and are the most cancerous PAHs. Degradation of long chained PAHs may cause an increase in the dispersion since the chains breaks into smaller chains and become more mobile. PAH-Ls are volatile (Naturvårdsverket 2009a). Until 1973, coal tar, which contains PAHs, was used as an asphalt binder in pavement construction in Sweden. By the time it was banned, it had already been used on Swedish roads for over 50 years and consequently, a lot of older roads still contain layers of the old asphalt binder and thus also commonly found in landfills today (Jacobsson Granvik 2003).

2.6.4 Chlorinated Aliphatic Hydrocarbons

Chlorinated aliphatic hydrocarbons (CAHs) are hydrocarbons with a varying number of chlorine atoms attached to it. Because of its toxicity, many of the CAHs have now been banned, but due to prior usage and leakage of the persistent solvents, they can still be found in the environment. Chlorinated solvents are often referred to as dense nonaqueous phase liquids (DNAPLs) since they have a higher density than water. Also, due to their hydrophobic properties, they often travel very fast and deep in a free phase through the soil profile and through the groundwater. Despite their low water solubility, even small concentrations of the solvents can cause adverse health risks to living organisms. Many of the substances are volatile (Åtgärdsportalen 2018c and Englöv et al. 2007).

2.6.5 PCBs

PCBs, polychlorinated biphenyls, are persistent and difficult to degrade. Since PCBs are nonflammable and have a low conductivity, they have been extensively used (Nationalencyklopedin n.d.e). PCBs bioaccumulate in the fatty tissues in living organisms, especially in fish and then undergo biomagnification in the food chain. They are therefore especially toxic to species at the top of the food chain and many PCB congeners have been proven to be cancerous to humans. Consequently, PCBs were banned in 1978 since they are one of the worst environmental toxins ever existed (Naturvårdsverket 2019a). Since PCBs readily bind to particles, their dispersion is mainly through dust and particle transport in groundwater (SGF - Åtgärdsportalen 2018f). Seven of the most commonly used PCB congeners, are normally analyzed in a PCB-7 investigation (Naturvårdsverket 2009a).

2.6.6 Chlorinated pesticides

Chlorinated pesticides are divided into fungicides, herbicides and insecticides and are frequently used in agriculture and industries. These have a great variety in chemistry and toxicity, but what they have in common is their persistence and potential to bioaccumulate in the food chain (Shahpoury et al. 2013). Chlorinated pesticides are very toxic to living organisms and have shown to be cancerogenic to humans (SGF - Åtgärdsportalen 2018d). One of the most frequently found pesticides in the environment is the now banned 2,6-dichlorobenzamide (BAM). No pesticides occur naturally in the environment, which was the general idea when the guideline values regarding acceptable concentration of pesticides in the groundwater was developed. For a long time, the detection limit for a pesticide was at 0.1 µg/l, which is why the guideline value for drinking water is set at 0.1 µg/l for an individual pesticide (Larsson et al. 2014).

2.6.7 Arsenic (As)

Arsenic is a heavy metal, often found in old pesticides products and in vicinity to mines. High doses of exposure of arsenic can be toxic to animals and humans as it is cancerogenic. In oxygen-rich soils with a pH below 8, arsenic is strongly bound to the soil as the arsenic is absorbed to Fe and Al oxides (Berggren Kleja, et al. 2008).

2.6.8 Lead (Pb)

The heavy metal lead is toxic even at very low concentrations and is bioaccumulating in living organisms. Lead is often found in high doses in leakage from landfills with residues from glass industries. Even at low pH, the cation (Pb2 +) binds strongly to both organic particles and Fe, Al and Mn oxides. The transport through soil and water is therefore largely by DOC or by colloids with iron oxides and humus substances. (Berggren Kleja et al. 2008)

2.6.9 Cadmium (Cd)

Cadmium is a heavy metal used in plastics, in fertilizers and in fossil fuels and is toxic to animals. In soils with high pH and in anaerobic environments, cadmium is strongly bound to the soil as it is forms complex with organic particles. In reducing environments, sulfides are readily precipitated. In contrast, in presence of oxygen along with a low pH, cadmium will be easily soluble (Berggren Kleja et al. 2008).

2.6.10 Copper (Cu)

Copper is a metal commonly used in wood impregnation, mines as well as in electronics. In the soil, copper is strongly bounded to humic substances even at low pH levels. Consequently, coppers main way of transportation through water and soil is by humic particles. Copper also binds to Fe, Al and Mn oxides but not as strong as it binds to humic substances (Berggren Kleja et al. 2008).

2.6.11 Chromium (Cr)

Chromium is found in wood impregnation, mining waste and is a common additive in steel. It is an essential nutrient but cancerogenic in high doses. In soils with low pH values and in anaerobic conditions, chromium is strongly bound to organic material as chromium (III) but becomes easily mobile in the more toxic form chromate (chromium VI) in dry soils and at higher pH levels (Naturvårdsverket 2009a and Berggren Kleja, et al. 2008).

2.6.12 Mercury (Hg)

Mercury has been used in a wide range of applications, such as chlor-alkali processes, batteries, electrical components, lamps and thermometers as well as emissions from gold mining and combustion of fossil fuels. The heavy metal bioaccumulates in the food chain and is highly toxic to living organisms by permanently damaging the central nervous system and the kidneys (Berggren Kleja, et al. 2008). Since 2009, the use of mercury has been banned in Sweden, but it is still frequently found in the environment. Mercury forms stable complexes with humic substances and accumulates in the soil surface layer. The humic particles are then easily transported with precipitation and soil water to adjacent watercourses. Unlike other heavy metals, mercury is soluble in water, which increases its mobility (Nationalencyklopedin n.d.d).

2.6.13 Zinc (Zn)

The biggest source of zinc emissions originates from car tires, wood impregnation and leachate from galvanized metal products. Zinc is an essential substance for plants and animals and is not particularly toxic to mammals, but freshwater organisms are sensitive to high concentrations of zinc. The solubility of zinc is strongly dependent to the pH level in the soil: the lower the pH, the higher solubility (Berggren Kleja, et al. 2008).

3 BACKGROUND

3.1 GENERAL INFORMATION OF RÖSABERG INERTA MASSOR

Rösaberg inerta massor is located northeast of Vetlanda city and its eastern wing is situated about 10 m from the protected river Emån (*Figure 1)*. It is unknown when the landfill was established and closed, but historical aerial pictures show that there was no activity on the land 1959 and that the landfill was active in 1973 and had grown in size by 1977. It was long believed that the landfill contained non-hazardous, inert, waste only, hence the name. Later, it was discovered that the landfill in fact contained mixed household waste as well. When the landfill closed, it was covered with filling materials and consequently, the structure was evened out and the underlying masses compacted. Since the closing, unauthorized deposition of household waste has occurred. This littering was recently removed by a project initiated by the municipality. Due to the probable large content of household waste, the suspected contaminants in the landfill was heavy metals (lead, cadmium, copper, chromium, mercury, nickel and zinc), organic hydrocarbons (organic carbon compounds) and nutrients (ammonium nitrogen) in the soil and groundwater, as well as dioxins, furans and PAHs (ÅF 2017).

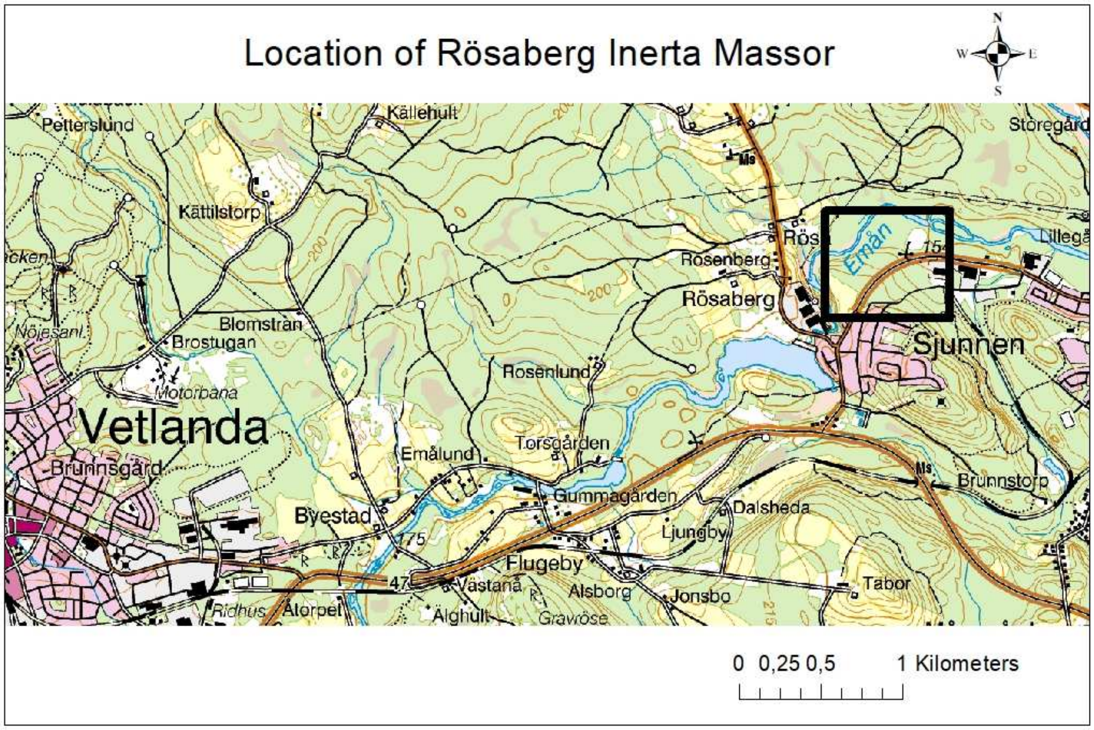


Figure 1: *Rösaberg inerta massor (marked area) is located northeast of Vetlanda city and 10 m from river Emån. Map from GSD-Terrängkartan, raster © Lantmäteriet (2016).*

3.1.1 Previous assessments

The first step of MIFO, Method of Surveying Contaminated Sites, was completed by Anna K Eriksson at ÅF 2017 (ÅF 2017). It is an orientation study of the contaminated site with an overall assessment of its risk. Different risk parameters were considered in an overall risk assessment, such as hazardousness of contaminants, contaminant level, as well as the risk the site poses on environmental receptors and humans. The overall risk resulted in the highest classification, risk 1, which implies that the site should be considered a very high risk to humans and the environment (see summarized evaluation diagram, *Figure 2)*. *Rösaberg inerta massor* have therefore been listed in the county administrative boards' national database EBH, where all identified contaminated sites are documented (Länsstyrelsen i Jönköpings län n.d.).

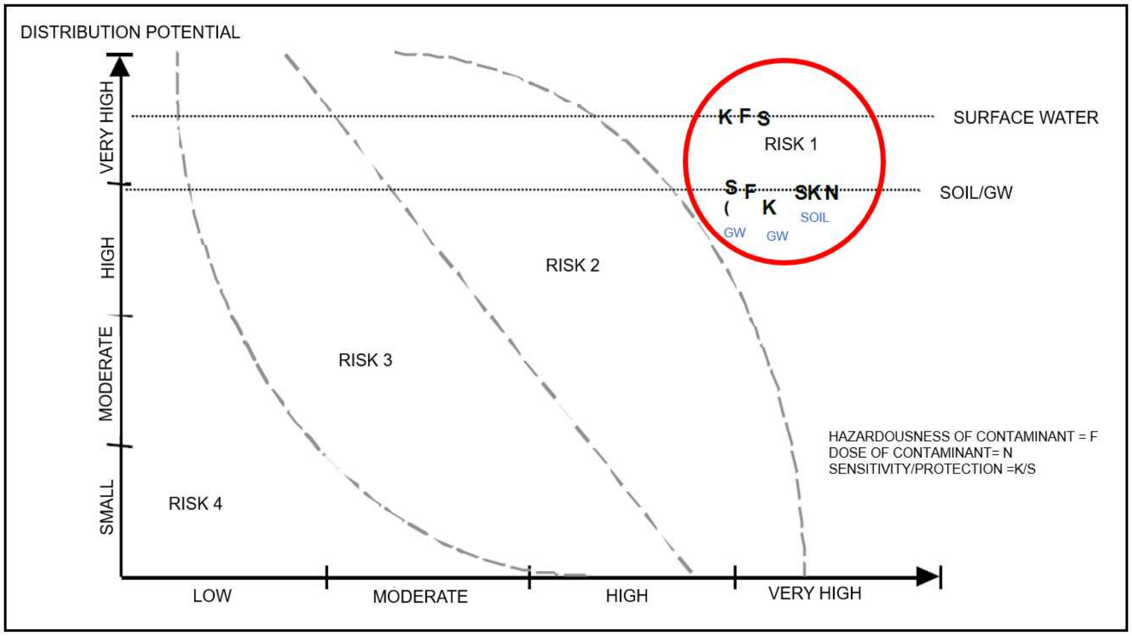


Figure 2: *Risk assessment diagram from the orientational study of the site (ÅF 2017). The risk parameters considered in the evaluated risk assessment was: hazardousness of contaminant (F), contaminant level (N) as well as the risk the site poses on environmental receptors (S) and humans (K) Since all risk parameters was evaluated to very high, the overall assessment of the site reached a risk 1.*

No samples on *Rösaberg inerta massor* were conducted in the MIFO 1-assessment, but other landfills of proximity and with properties assumed to be alike *Rösaberg inerta massor* had been sampled before and showed very high levels of hazardous contaminants (ÅF 2017).

3.1.2 Construction of the landfill

According to the MIFO 1 assessment, the landfill is separated into two different parts: The eastern and the western part, where the eastern part is the oldest. Aerial photographs from 1959 and 1973 show that the establishment of the eastern landfill must have happened in this timeframe, with one part deposited around 2002[1]. The masses from the western part of the landfill is believed to have been deposited during 1973 to 1977. By investigating LIDAR-pictures, the MIFO 1 assessment had recognized that the eastern landfill was divided into

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[1] Thomas Svensson (Vetlanda Municipality, e-mail 2020-04-15)

different stages dependent on the date of the waste disposal. The bottom, and the oldest stage (5 m deep), was believed to contain both household waste and inert waste. It is this stage that was visible in the aerial photograph from 1973. The second stage (6 m deep) was believed to only contain inert waste (ÅF 2017). The third a stage (2 m deep) was believed to have been deposited 2002 and contain disposed, excavated soil material. Stage 4 was presumed to contain surplus masses (ÅF 2017). The different stages are visualized in a conceptual model over the contaminant situation in *Figure 3*.'

3.1.3 Hydrogeologic description of the area

The landfill lays on top of a sandy till soil (ÅF 2017). Sandy till has a hydraulic conductivity of 10^{-4}-10^{-8} m/s which implies a large permeability, and the rate of dispersion to the groundwater and soil is then approximately 0.01-1 m/year (Naturvårdsverket 1999). With the proximity to river Emån of 10 m, the risk is large that the water has been contaminated by leachate from the landfill. The runoff water from the top surface of the landfill is estimated to flow from the southwest to northeast, where the landfill meets the river. The landfill is located on top of a groundwater aquifer (ÅF 2017). On the northwest side of the landfill, a larger asphalted road is located. This could have the properties to act like a groundwater barrier to the region, restricting ground- and runoff water from the other side of the road to recharge the groundwater aquifer under the landfill. This, however, is not confirmed.

The river Emån was measured at a discharge mean of 11.5 m^3/s in the SMHI station 2406 bit downstream of *Rösaberg inerta massor*. The mean high discharge was measured to MHQ: 30.8 m^3/s and mean low discharge MLQ: 2.8 m^3/s. The values are a calculated from the daily discharge between 1981-2018 (SMHI 2020a).

3.1.4 Future land use and overall remedial goals

The remedial goal for *Rösaberg inerta massor* is to prevent any harm that the landfill may cause humans and the nearby environment. Due to the high-risk classification that was set during MIFO 1, it is necessary for further, more in depth investigations to be conducted and a MIFO 2 was therefore advocated. The area is currently only visited by occasional by-passers entering the area as well as unauthorized sports activities, such as motocross that occurs in the nearby forest with trails that leads to, and on top of, the landfill. There are no plans for the future land use in the region that will change the human activity on the site. A road barrier is blocking the access to the landfill from the main road to avoid unwarranted vehicles to enter. Consequently, it is assumed that the human exposure and residence time of the site will proceed to be relatively low[2].

3.2 PROTECTION

The receptors that would be accounted for in a risk assessment of the site are the following:

- Protection of humans
- Protection of the soil environment
- Protection of groundwater
- Protection of surface water and sediment

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[2] Thomas Svensson (Vetlanda Municipality, meeting 2020-02-25)

A conceptual model was created to visualize an overall picture of the receptors and the exposure pathways in the area (see *Figure 3).*

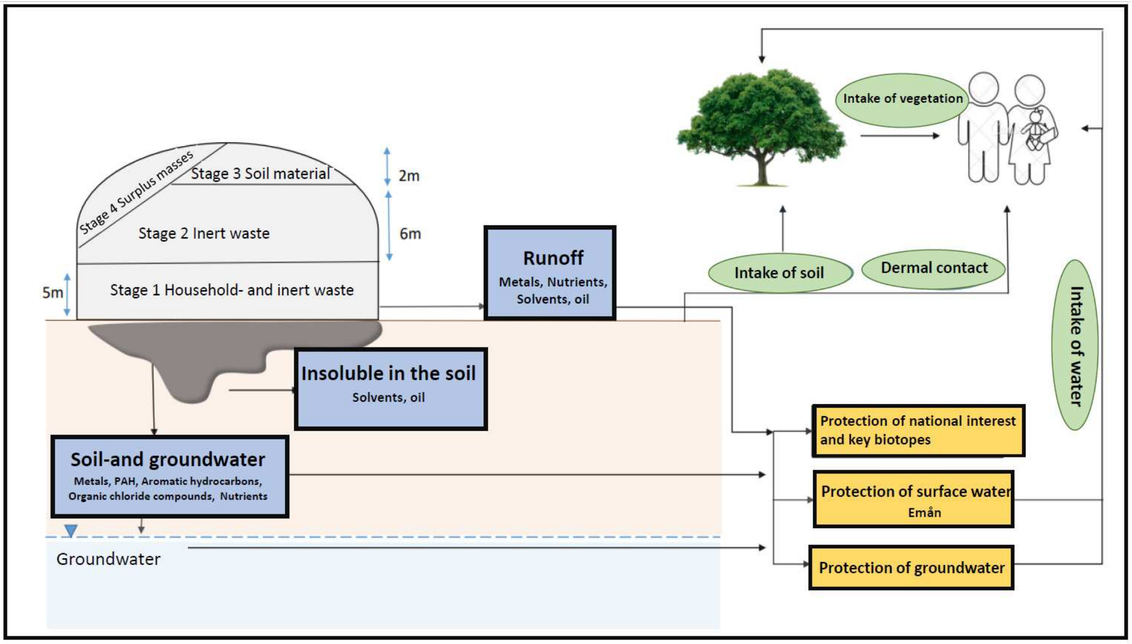


Figure 3: *Overview of the receptors and exposure pathways of the area.*

The general aim is to avoid any negative effects that a contaminant may cause humans, soil environment and the surface-and groundwater. In practice however, it is not always realistic to have a zero risk aim and therefore, guidelines of what level of risk that is acceptable for different receptors have been established (Naturvårdsverket 2009b).

3.2.1 Protection of humans

Protection of human health covers all types of exposure that may occur of the contaminated site, which includes both direct and indirect contact. Direct exposure happens at the contaminated site, indirect contact can happen remote from the site, when the contaminant has spread via water or air. The effect that a contaminant may have on human health varies depending on the substance, which dose it is and how regularly the individual is exposed to the contaminant. While determining the risk that a contaminated site has on human health, the expected exposure pathways as well as exposure frequency is therefore of essence (Naturvårdsverket 2009b).

The main human exposure pathways of hazardous contaminants in the area of *Rösaberg inerta massor* was assessed in this study to be mainly by dermal contact as well as intake of soil, plants and water (runoff water, groundwater and river Emån). Inhalation of dust and gases are also normally a prominent exposure pathway but are not considered a large concern in *Rösaberg inerta massor* since the area is well vegetated.

3.2.2 Protection of the soil environment

The objective to protect the soil environment is to conserve the natural functions of its ecosystem, such as degradation of organic material, production of oxygen, as well as circulation of nitrogen and phosphorus. In addition, the level of toxins in the area should not pose an unproportionable risk to the endangered or protected species living in the area (Naturvårdsverket 2009b). Standard protection guidelines express which threshold values that are allowed for different contaminants according to how large a proportion of terrestrial species, mammals and birds in the ecosystem that should be protected (Naturvårdsverket 2009a). This means that some negative impacts on the ecosystem are tolerated, due to making the goals more achievable. In places where the interest of protection is greater than the standard, site-specific guidelines can be beneficial to use. Then, new guidelines are developed with the site's specific properties in mind. That includes areas with a high biodiversity or that are regarded to be of national interests in terms of nature conservation (Naturvårdsverket 2009b).

There are plenty of receptors in the area around Emån which needs special consideration (Naturvårdsverket n.d.):

- Natura 2000, conservation of natural habitats and of wild fauna and flora
- National interest – Natural value
- Key biotope

3.2.2.1 Natura 2000, conservation of natural habitats and of wild fauna and flora

The river Emån is protected under Natura 2000, conservation of natural habitats and of wild fauna and flora directive provided by the European Union (Länsstyrelsen I Jönköpings län 2016). This directive (directive 92/43/EEG) aims to protect water courses as well as endangered species and habitats in the European Union (European commission 2019c).

The protected species in Emån are invertebrates freshwater pearl mussels and unio crassus as well as otters (Länsstyrelsen I Jönköpings län 2016).

3.2.2.2 National interest – Natural value

Areas of national interest in terms of nature conservational purposes are selected by the Swedish EPA along with the county administrative boards and municipalities. The areas are chosen according to how well they represent the Swedish nature, diversity and landscape (Naturvårdsverket 2018a).

For the Emån area, fauna is of national interest in the watercourse, while flora is of interest by the beach side and the adjacent land area (Naturvårdsverket 2000).

3.2.2.3 Key Biotope

The inventory of key biotopes in Sweden started as initiative of the Swedish forest Agency in the early 1990s (Gustafsson and Hannerz 2018). A key biotope is a forest that, due to its properties, such as species diversity or structure, plays an important role to the flora and fauna (Skogsstyrelsen 2019).

The key biotope identified in the river Emån was pinpointed because it includes a beach forest and a carr. The area is located on a river delta and has a bouquet-shaped structure and with its dry-stone walls gives the area a cultural-historical value (Skogsstyrelsen 1994).

3.2.3 Protection of groundwater

3.2.3.1 Swedish goals

The Swedish government has formulated 16 environmental quality objectives which highlights current environmental issues in Sweden. One of them reads *Good-quality Groundwater* and is described from the Swedish parliament as follows:

> "Groundwater must provide a safe and sustainable supply of drinking water and contribute to viable habitats for flora and fauna in lakes and watercourses" (Naturvårdsverket 2018b, p.17).

To reach this goal, specific demands on the country's groundwater quality and quantity as well as water level and chemistry have been determined (Lång et al. 2019). It is primarily the responsibility of the operator or landowner to protect the groundwater of the area, in accordance with Chapter 2, Section 3 of the Environmental Code (Miljö- och energidepartementet 1998).

3.2.3.2 EU directives

Water Framework Directive (WFD) was created with the foundation that groundwater does not only have a value in terms of a drinking water resource but also has an environmental value in itself. The directive aims to achieve good ecological and chemical status for all waters in the EU (European commission 2019b). In 2006, WFD formed another directive, called *The Groundwater Directive* with the purpose to clarify what good chemical status means in practice, and a range of technical specifications were established. One of the key goals is to protect all groundwater from hazardous contaminants in order to protect the environment and human health (European Commission 2006).

Regarding the area around Emån, a groundwater aquifer is located below and east of the landfill. Consequently, there is a large risk of groundwater contamination. Also, the groundwater is believed to reach Emån.

3.2.4 Protection of surface water and sediment

As one of the largest watercourses in southern Sweden and with a substantial cultural heritage and a profound wildlife, the interest to protect Emån is big. The catchment area includes over 900 lakes and covers 4 470 square kilometers in eight municipalities before it eventually ends up in the Baltic Sea. The river is used to extract drinking water, fishing, irrigation and recreation along its course. It is also a recipient of runoff water, wastewater and process water from industries from its catchment area, emissions which inevitably will cause a liability on Emån's water quality. *The Emåförbundet initiative* was therefore developed with the objective to control the quality of the stream (Emåförbundet 2016).

3.2.4.1 Swedish goals

Just like groundwater, the protection of surface water is described by the Swedish government in the 16 environmental quality objectives. *Flourishing lakes and streams* describe the overall goal which is to protect the diversity of the ecosystems in all watercourses as well as the cultural values. The goal continues in several detailed goals that describe minimum criteria of ecological and chemical status for lakes and watercourses, its water quality and quantity and the conservation of its ecosystem services (Havs- och vattenmyndigheten 2019).

3.2.4.2 EU directives

River Emån, as well as all water bodies in the EU, is also covered by the WFD. The protection of surface water is described in the Water Framework Directive. The aim is to, among other things, prevent deterioration in the status of all surface water bodies and to reduce pollution and emissions of hazardous substances (European Commission 2000).

It is therefore of both national and international interest to protect river Emån from contaminants. The receptors are summarized in *Figure 4.*

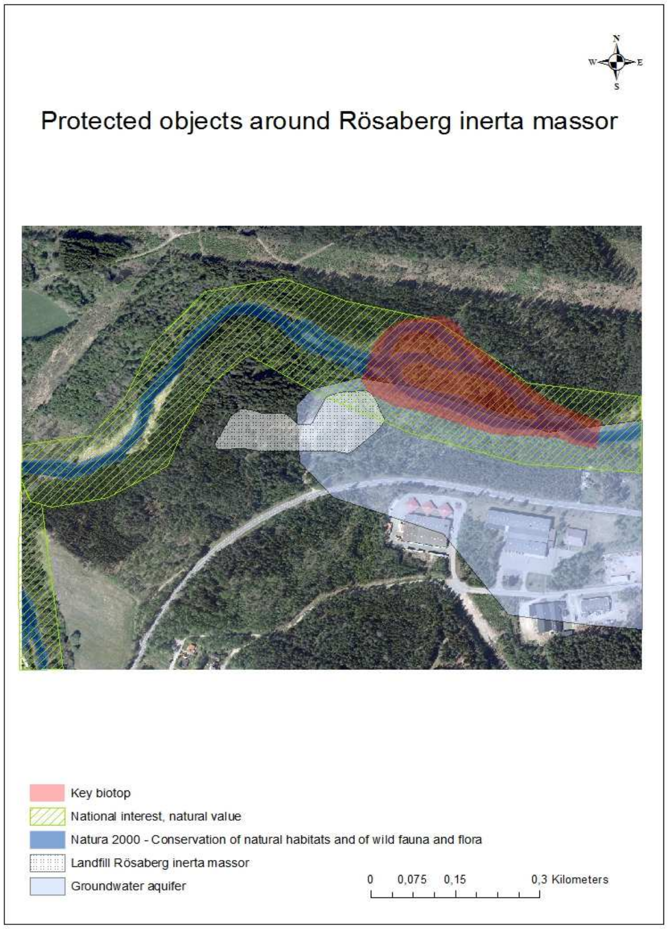


Figure 4: *Identified receptors adjacent to Rösaberg inerta massor. Background map: Ortofoto ©Sveriges Geologiska Undersökning (2019). Soil type layer showing landfill size and river Emån: Jordarter 1:25 000-1:100 0000. ©Sveriges Geologiska Undersökning (2014). Groundwater aquifer: Grundvattenmagasin ©Sveriges Geologiska Undersökning (2015). Key biotope and Natural interest locations are manually mapped out according to Naturvårdsverket (n.d.).*

3.3 GUIDELINE VALUES

In order to protect human health, soil environment as well as water bodies, guideline values have been created to classify the effects of contaminant levels, hazardous masses and the risk that different doses may pose.

3.3.1 National guidelines

The Swedish EPA has developed national guideline values establishing acceptable contaminant concentrations on different types of land usages regarding human activity, the soil environment and waters. These guidelines can be found in the Swedish EPA report 5976. The guidelines are based on general conditions in Swedish soils above the groundwater and is adapted to what type of plans that is set for the contaminated area for the future. The Swedish national guideline values have therefore been divided into two different types of land use, where the guideline values designated to *sensitive land use* (KM, from Swedish *känslig markanvändning*), are set higher than *less sensitive land use* (MKM, from Swedish *mindre känslig markanvändning*). Depending on how the soil is classified, the guidelines are set differently (Naturvårdsverket 2009a).

For KM, all types of activities should be possible to pursue. That means that children, adults and elderly should be able to live and be active in the area for an unlimited period of time without getting affected by the contaminants. The soil should be clean enough for edible crops to be cultivated and the groundwater should be drinkable. In addition, most land ecosystems, surface water and their organisms are protected. When it comes to wildlife, 75% of the species is aimed to be protected in the area (Naturvårdsverket 2009a).

For MKM, the use is limited to offices, industries or roads. The exposure time of the contaminant is therefore constrained to only working hours as well as for children and the elderly to only temporarily visit the area. The area’s surface water with its organisms and groundwater at 200 meters downstream are still protected, but extraction of groundwater as drinking water is not expected. Soil environment is not as protected, and it is assumed that vegetation in the area can be consumed. When it comes to wildlife, 50% of the species is aimed to be protected in the area. (Naturvårdsverket 2009a).

3.3.2 Site-specific guidelines

Site-specific guideline values can be generated in those areas whose characteristics are not applicable to the national guideline values. A model where these site-specific guidelines can be calculated have been developed by the Swedish EPA (Naturvårdsverket 2019b), where the properties of the specific site is considered. In this way, the exposure paths and receptors can be modified to mirror the true characteristics of the site and its future land use. For instance, in areas that are heavily polluted, the requirement for the soil environment can be lowered or completely removed if necessary (Naturvårdsverket 2009a).

3.3.3 Classification of masses

The masses of a landfill are divided into either containing non-hazardous waste (IFA, from Swedish *icke farligt avfall*) or hazardous waste (FA, from Swedish *farligt avfall*). How this is assessed is described in the EU Directive 2008/98/EC (European Commission 2008) and in the waste ordinance (SFS 2011:927) found in the Swedish legislation. The assessment is based on the questions: 1. What type of contaminants, and in what concentration, are found in the masses? 2. Does the contaminants have any hazardous properties such as explosiveness, cancerous or ecotoxic? In many scenarios, the contaminant does not obtain its hazardous properties until it has reached a certain concentration, or if it is mixed with other contaminants in the waste. Therefore, the Swedish Waste Management Association has produced recommended guideline values for what concentrations in the waste that are considered hazardous (Avfall Sverige 2019).

The Swedish EPA has described scenarios for when the risk derived from a contaminant is considered so small that there is no obligation to report the contaminant to authorities in the municipality. This scenario is called MRR (less than little risk, from Swedish *mindre än ringa* risk). These values have been calculated based on standardized properties of contaminated areas and assumes that no other substantial contaminants alter its risk are present nor that the site has any special receptors to take into consideration, such as water protection areas, flood risk areas and Natura 2000 sites. The guideline values for MRR can be found in Swedish EPA handbook 2010:1 (Naturvårdsverket 2010).

Non-hazardous masses are classified as inert if the masses can be stored without physically, chemically or biologically changing (Viavest n.d.). Regulations regarding whether the masses are in fact inert or not depends on rate of leachate. Allowed leachate rates can be found in the Swedish EPA’s constitutional collection NFS 2004:10 regarding landfills (Naturvårdsverket 2004).

3.3.4 Quality classification of groundwater

In order to control the groundwater in line with EU Water Framework Directive (2000/60/EG) and the Groundwater Directive (2006/118/EG), a quality classification system was developed 1999 by the Swedish EPA and updated 2013 by the Geological Survey of Sweden (SGU, Sveriges Geologiska Undersökning). The objective of classifying the quality of the groundwaters is to enable authorities to locally assess their groundwater resources as well as easily pinpoint areas where remediation is prioritized. In 1999, the Swedish EPA developed classifications regards the groundwater quality in terms of its health standard as drinking water. Here, the guideline values for the drinking quality is ranked from less severe, moderately severe, severe, and very severe. The classification for the SGU system is based on reference data obtained across Sweden and includes all types of substances that may occur in the groundwater, both natural and anthropogenic substances. The classification rate is based on standardized background levels (for naturally occurring substances only) as well as its environmental and health effects and impacts due to the substance. The limit for when water no longer is suitable for drinking is at the classification 5 (Sveriges Geologiska Undersökning 2013).

3.3.5 Classification of groundwater depending on usage

The Swedish Petroleum Institute (SPI) have created guidelines regarding the various usage of groundwater. The guidelines are set for concentrations at the source of pollution and relate to different exposure paths of groundwater, such as vapor penetration into buildings, irrigation, drinking water, surface water and wetlands (Svenska Petroleum Institutet 2010). The guidelines are set especially for sites with petrol and diesel stations, but since many landfills contain waste from vehicles, it may be motivated to look at these guidelines.

4 METHOD

4.1 SITE INVESTIGATION

The selected sampling strategy implemented for the site investigation was an assessment-based approach, which includes the *targeted sampling method*. This means that samples are strategically placed throughout the site with the objective to confirm or delimit suspected contaminated areas within the site. They can also be placed on locations where the properties are of interest to identify, for example where leachate is believed to be large. The decision of where the test points should be placed is therefore subjective and should be based on previous studies and knowledge of the site (Norrman et al. 2009).

4.1.1 Sampling #1

On the 2020-03-25, sampling of the landfill was conducted in collaboration with Njudung Energi and Vetlanda municipality. A field protocol describing the visual assessment can be found in *APPENDIX F*. The purpose of the first site investigation was the following:

- Visual assessment of material, topography, soil type layers, detect visual hotspots in the area as well as excavate trial pits on locations considered interesting
- Execute PID-analysis on soil from every trial pit to identify volatile substances
- Collect soil and water samples from trial pits where it was considered relevant
- Install three groundwater monitoring wells
- Measure the groundwater table in the monitoring wells
- Obtain coordinates for each trial pit

4.1.1.1 Material and instruments used

- GPS, version Topcon GRS-1 (Topcon Totalcare 2020).
- PID (AE MiniRAE Lite Portable Handheld VOC Monitor (PGM-7350 Series), calibrated with Isobutylen ($C4H8$)100 PPM, oxygen 20.9 %, Nitrogen 79.09 %.)
- Water level tape measurer
- Groundwater monitoring wells: PEH screening (Ø: 63/50 mm, length: 1 m, slot: 0.3 mm), PEH casings (Ø: 63/50 mm), caps and pointed end caps
- Sampling vessels obtained from Eurofins AB

In order to prevent injuries and accidents related to going down in an excavated trial pit, soil samples were taken from the mound of soil that was dug up by the excavator (Svenska Geotekniska Föreningen 2013). From each trial pit, several sub-samples were collected from the mound of excavated soil and mixed into a composite sample representing the individual trial pit. In this way, soil from different levels of the pit could be included. Advantages of this methodology is that estimations of the properties of the soil profile can be obtained when it is not financially possible or reasonable to analyze every individual soil level of 0.5 m separately (United States Environmental Protection Agency 1995, Naturvårdsverket 1994).

For each pit, soil was collected into a plastic bag in order to examine its concentration of volatile organic compounds using a photoionization detector (PID). PID sends out a ray of ultraviolet light with the purpose to ionize the chemicals in the gas emitted from the sample. The number of charged ions in the gas can then be measured by the PID (Laird and Verhappen 2010) (see *Table 2* for the result).

The trial pits (PG1GW, PG2GW, PG3GW) were dug on the eastern side of the landfill. Before closing the pits, PEH-plastic groundwater monitoring wells were installed. Installing groundwater wells in trial pits are normally not recommended since the stirring might influence the results. However, it can be done if it is installed correctly (Svenska Geotekniska Föreningen 2013). The monitoring well contained one screening part with a filter material with 0.3 mm slots suitable for groundwater to infiltrate. On the bottom of the well, a pointed end cap was attached. The screening part of a monitoring well should be placed by the groundwater level in order to let the groundwater flow into the well. Since the groundwater level may fluctuate throughout the seasons, the screening part needs to cover a larger length of the profile than just the current level of the groundwater (Naturvårdsverket 1999). The screening part should not cover the whole profile however, which would allow soil water to infiltrate the well too. Therefore, the upper (casing) part of the well does not have any slots. The dimensions of the wells varied between 4-5 m (*Table 3).*

The groundwater monitoring wells were inserted by hand and stuck down at the bottom of the pit which had about 30 cm infiltrated groundwater. To stabilize the well tubes, a filter material was taken from an adjacent gravel pile and filled around the screening part in order to avoid large blocks and stones that may damage the well or affect the groundwater flow. The rest of the pit was filled with the original, excavated soil. The groundwater table was measured with a water level measuring tape a few hours later in order to get a rough estimation if the installation had been successful. The measuring device detected water (*Table 3*) and did not show any signs to be crooked or damaged by any large rocks.

In two pits, PG5 and PG8, accumulated water from the bottom of the pit was collected in plastic vessels. The water, which has the possibility to be a mixture of both groundwater and leachate, was taken up by the mechanical diggers shovel and sent for analysis.

Table 2: *Summary of each sample point from the site investigation 2020-03-25.*

	PG1GW	**PG2GW**	**PG3GW**	**PG4**	**PG5**	**PG6**	**PG7**	**PG8**
Approx. Pit depth	4.5 m	3.8 m	3.9 m	3.2 m	2.5 m	2.5 m	3.5 m	4.5 m
PID (ppm)	7.6	0	0	0	0	0	0	0
GW-well	Yes	Yes	Yes	No	No	No	No	No
Soil sample	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Water sample	No	No	No	No	Yes	No	No	Yes

The coordinates of the trial pit locations were measured with GPS and imported into ArcMap 10.7 (*Figure 5*). When GPS-points were studied in ArcMap with the background layers showing the size of the landfill according to *Figure 4*, it was noticed that the true size of the landfill is in fact larger. To fit the GPS-points where they were located according to visual inspection during the site investigation, a larger polygon representing the landfill was made in ArcMap. This is also visualized in *Figure 5.*

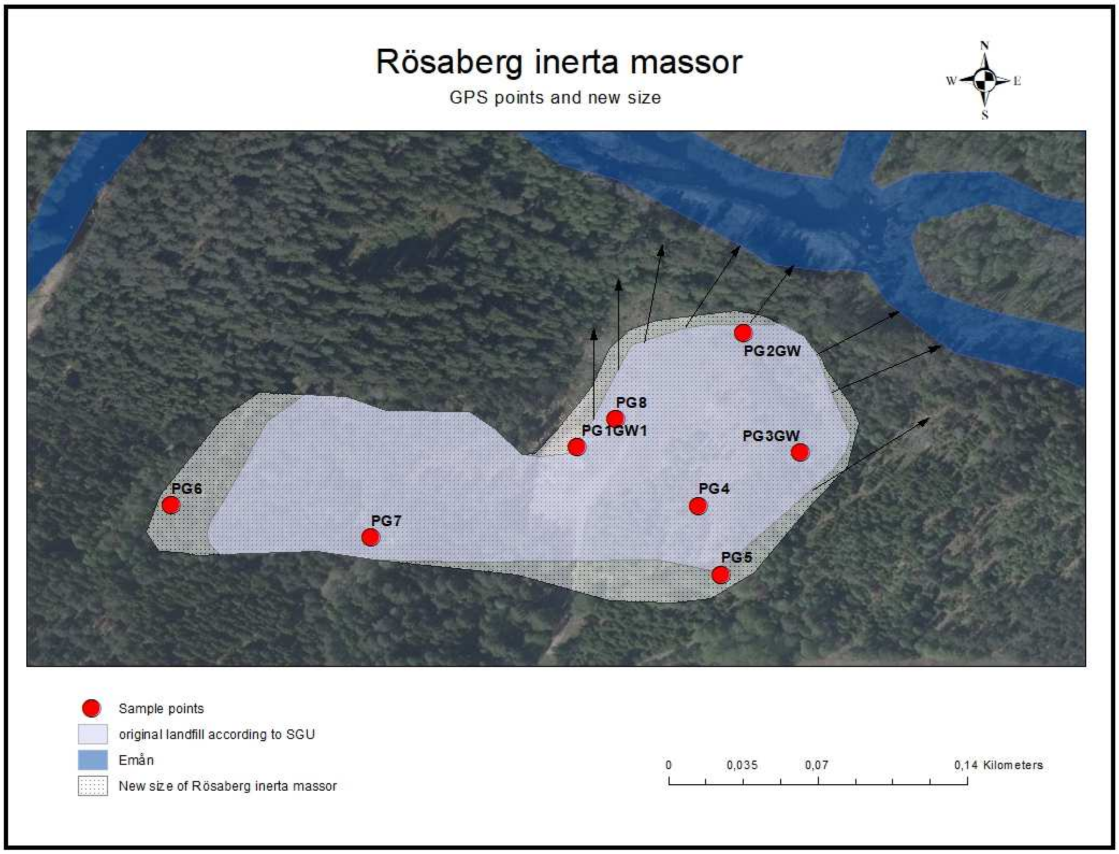


Figure 5: *Locations of sample points measured with GPS. The map visualizes the new size of the landfill as well as its old estimated size. Soil type layer showing original landfill size and river Emån: Jordarter 1:25 000-1:100 0000. ©Sveriges Geologiska Undersökning (2014). Background map: Ortofoto ©Sveriges Geologiska Undersökning (2019). Arrows show presumed groundwater and runoff flow path.*

4.1.2 Sampling #2

The following week, 2020-03-31, water samples were taken from the groundwater monitoring wells. The purpose of this sampling was as follows:

- Collect groundwater samples from each groundwater monitoring well
- Measure the groundwater table

4.1.2.1 Materials and instruments used:

- Peristaltic pump model Watson Marlow (313B2 BARE SHAFT P/HEAD)
- Pump hose - Watson Marlow Marprene, inner diameter: 8 mm
- Suction pipe- LLDPE, outer diameter: 8 mm
- Vessels (1000 ml glass bottle, 100 ml brown glass bottle, 50 ml plastic tube, HG bottle, 250 ml special plastic bottle with preservative)
- Water table tape measurer

Water samples were not taken in conjunction to the installation of the wells the previous week. The reason for that was to give the groundwater have time to restabilize. Digging of trial pits results in a stirring and agitation of the soil and groundwater and can lead to misleading values if the groundwater is sampled too quickly. Robert Gass (Njudung Energi) and Thomas Svensson (Vetlanda municipality) offered to perform the sampling as well as recirculating the wells by prepumping water from the wells. Prepumping of wells is an essential procedure before collecting groundwater samples. Otherwise, stagnated water may be collected which can influence the results. On 2020-03-30, the wells were prepumped with a peristaltic pump. During this day, the groundwater table was investigated with a tape measurer and gave results according to *Table 3.* The water samples were taken 2020-03-31. The first well (GP1GW) contained enough water to take all samples in one go. The other two wells however, the refill of groundwater in the wells took a bit longer. Therefore, the sampling happened in two attempts.

Table 3: *Length of monitoring well and measured parameters of groundwater tables. Groundwater table was measured in m over the surface.*

	PG1GW	**PG2GW**	**PG3GW**
GW-well	3 m screening 2 m casing	2 m screening 2 m casing	2 m screening 2 m casing
Well height over surface	0.45 m	0.4 m	0.12 m
GW table 2020-03-25	3.79 m	2.79 m	2.17 m
GW table 2020-03-30	3.81 m	2.78 m	2.18 m

4.2 ANALYSIS OF SAMPLES

A screening assessment of the metal content of the collected soil samples was performed 2020-03-26 using an X-ray fluorescence spectrometer (XRF, *SciAps X-200* portable XRF). The investigation gives an indication of the metal concentration of a soil sample but since it only analyses a small portion of the sample, the uncertainty can be worth noticing (Svenska Geotekniska Föreningen 2013). An XRF emits an X-ray photon beam towards the segment of the soil sample which becomes ionized. The instrument can then detect the specific energy released from the material's different atoms (Bruker 2020). The plastic bags containing the soil samples were shaken and then flattened on the floor before pointing the XRF at it and the results are presented in (*APPENDIX B.2).*

The soil, water and groundwater samples collected during the site investigations were sent for lab analysis at Eurofins (*APPENDIX G).*

4.3 HANDLING OF DATA

4.3.1 National guidelines

To assess the contamination level and risk of the site, the results from the analyzed soil and groundwater samples was compared to the national guideline values described in previous section.

4.3.2 Site-specific guidelines

To obtain adapted guidelines to the current properties of the site and its receptors, site-specific guidelines was derived for a selection of contaminants. The selection was done by choosing the top 25 contaminants with highest concentration relative to the national guidelines. The new guidelines were calculated in the Swedish EPA model (Naturvårdsverket 2019b). The scenario was limited to the eastern part of the landfill only, since this part was evaluated to have more similar properties as well as that more data and information was obtained from this area. The standard parameters in the model were used for a KM scenario, which is the most sensitive scenario. It was chosen due to the risk of groundwater dispersion to the adjacent receptors. Some deviations were done to the default KM parameters: the depth to contaminant was changed from the standard 0.35 m to 0.1 m since the contaminant was assumed to be constant throughout the whole soil profile, hence, even in the upper part of the profile. Second, because of the sloping structure of the landfill towards the river Emån, the whole soil profile will be exposed to the river when the water table is fluctuating in time and thus the depth of contaminant will be shallow. The size of the site was changed to 126.25 m x126.25 m, since the area of the eastern part is approximately 15 939 m^2 according to the GIS measuring tool (see map in *Figure 6* over how the eastern part was limited). The model resulted in new, site specific guidelines for soil, see *Table 6*. These were used while comparing the sampled soil concentrations in the result section *Table 7 - 8* and *APPENDIX B.2 – B.4.*

4.3.3 Description of GMS

GMS (Groundwater Modeling System) is a computational software that is used to simulate subsurface water, such as groundwater flow, calculate water supply in aquifers and track contaminant transport. The software was developed by the Environmental Modeling Research Laboratory (EMRL) in the late 1980s, which then merged into the new brand Aquaveo (Aquaveo 2019a). GMS supports a variety of models with different applications and functions. In this study, GMS 10.3.2 was used along with its MODFLOW 2000, MODPATH and MT3DMS.

4.3.4 Description of MODFLOW

The key model of GMS is MODFLOW. MODFLOW is a frequently used program to visualize and simulate hydrologic environments in three dimensions. The model mirrors the groundwater transport and the flows in the saturated zone with the objective to resemble the true properties of the hydrogeology of an area (Ekman 2004). The hydraulic head are either modeled as stationary (steady state) or transient. Steady state implies that the hydraulic conditions stay constant and that the system is balanced throughout the simulation, while a transient model allow fluxuations in the hydraulic heads and flow. In reality however, almost all hydraulic systems are transient but for the simplicity of this study, the model was set for steady state. The advantages of steady state simulations are that they need less data and can be relatively a good representation of a system over a longfer time period (Karlsson 2008). MODFLOW divides the region of interest into rows, columns and layers of cells, where each cell can be assigned appropriate attributes that mirrors the region. It is therefore essential to have enough information of the hydraulic and geological properties of the region, such as boundary conditions and recharge stresses. A large proportion of the modelling is therefore to calibrate the model until its properties mirror the real properties of the region, and the model is thereby validated.

For the purpose of this project, GMS was used to investigate the flow patterns of the eastern part of the landfill as well as the dispersion and concentration of a few selected contaminants 50 years from now. The investigation was limited to the eastern part of the landfill due to lack of groundwater data in the remaining part. The selection of contaminants that was based on the substances rate of exceedance of guidelines as well as their k_d-values. See *Figure 6* to see a map of the selected part of the landfill.

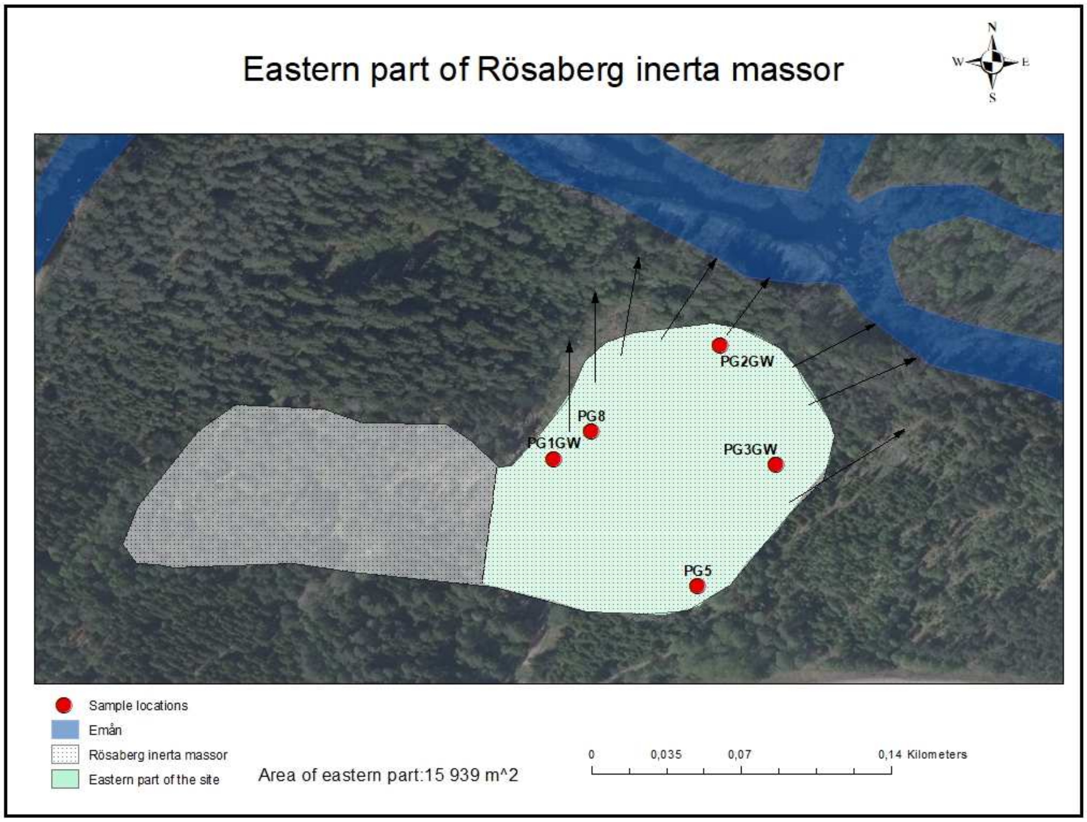


Figure 6: *Map over the eastern part of the landfill. Its area was measured to be 15939 m*^{2}*. The sample points used in GMS and site-specific guidelines are visual in the map. Arrows show presumed groundwater and runoff flow path. Background map: Ortofoto ©Sveriges Geologiska Undersökning (2019), River Emån: Jordarter 1:25 000 - 1:100 0000 ©Sveriges Geologiska Undersökning (2014).*

4.3.5 MODFLOW model

In MODFLOW, a coverage with the shape of the landfill was created. A 3D-grid was then fitted in the coverage with the dimensions of the landfill. Since the eastern landfill area was estimated to 15 939 m^2 (according to GIS-measuring tool), the grid dimensions were set accordingly (*APPENDIX D.2)*. The depth of the model was set to 8 m and was divided into two layers. The MODFLOW simulation was created with version 2000, with a forward run and a steady state model type. The bottom rows of the grid were assigned to represent the river Emån. To simplify the problem, it was assumed that the water surface of Emån is constant in time (151 m with RH 2000 from Lantmäteriet (2019)). Consequently, this was set as a reference while inserting the top elevation for layer one (soil surface). Top elevation for layer 2 was 0 according to the profile sketch in *Figure 7*. Top elevations were derived from GPS-measurements and was set for all known cells (with the height of the water surface as a reference) and an approximate estimation of elevation was done to the remaining cells where elevation was unknown. For hydraulic head, the cells representing the riverbed to Emån was set to constant 1 m, since a hydraulic head of 0 m, which would have been easier represented, was denied in the program. Due to this, the hydraulic heads for the groundwater was adapted, and 1 m was added to each starting head (*APPENDIX D.1).*

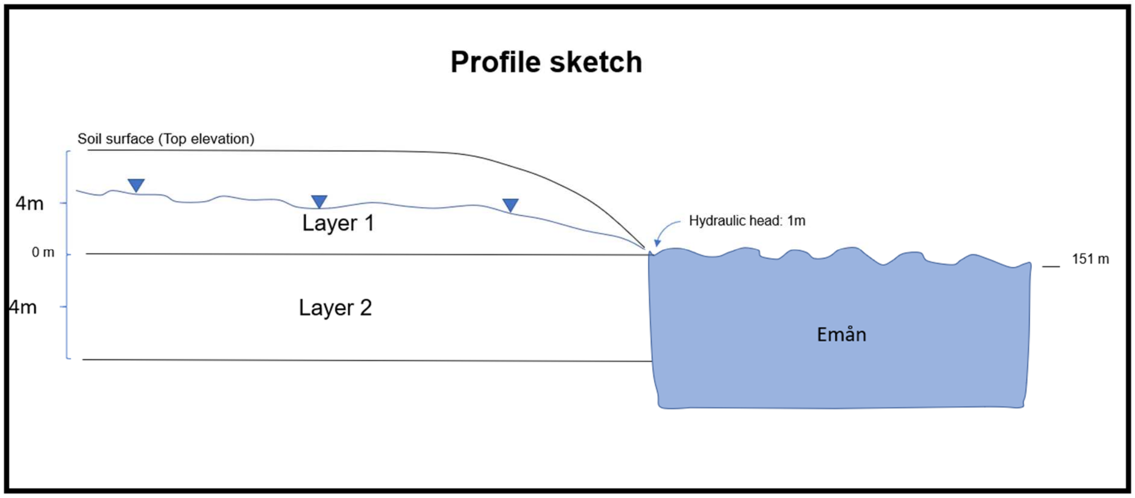


Figure 7: *Profile sketch over the groundwater layers implemented in MODFLOW.*

The boundary conditions for the sides of the landfill was assigned to have no flow (and was inactivated in the model) while the upper rows were still active. See *Figure 8* for model set up.

4.3.5.1 Soil characteristic parameters

For hydraulic conductivity (*K)*, different parameters were used for the different layers. In a laboratory study conducted by Reddy et al. (2009) the properties of a landfill of fresh municipal solid waste was analyzed. Here it was noted that *K* varied between 10^{-8} - 10^{-4} m/s. This was also confirmed by Staub et al. (2009) and was in line with the *K* that sandy till soil have, which was stated in the hydrogeological description of the site. According to Reddy et al. (2009) study, the hydraulic conductivity showed to be 10^{-5}-10^{-4} m/s of fresh MSW with a 0 kPa confining pressure and depth of 0 m. Furthermore, the hydraulic conductivity was 10^{-7} - 10^{-6} m/s at a depth of 8 m in a 67 kPa confining pressure. Due to this, a mean value of the two intervals were used to describe the horizontal hydraulic conductivity for the upper and lower layer respectively. The vertical hydraulic conductivity was estimated to be lower than the horizontal, since the water transportation direction in saturated soils are predominantly horizontal, as described in the theory section. Vertical hydraulic conductivity was set to be five times lower than the horizontal *Ks*.

Porosity and fraction of organic carbon of the soil was set to the standard values set by the Swedish EPA, where porosity: 0.4 (fraction) and fraction of organic carbon: 0.02 [-] (Naturvårdsverket 2009a). All parameters used are presented in *APPENDIX D.2*.

4.3.5.2 Recharge

Recharge of the groundwater aquifer occurs due to infiltration of rainfall as well as adjacent surrounding groundwater. The recharge from rainfall was derived from a 30-year mean (1961-1990) from the nearby water station Nävelsjö (SMHI 2020b) subtracted by the annual mean (1961-1990) evapotranspiration rate of the region from SMHI (2017), according to the water balance *Equation 3*. Assuming the storage of water was constant in Rösaberg, the rainfall resulted in a 0.0006961 m/d groundwater recharge and was assigned to all cells in the upper layer in MODFLOW.

$$R_{rain} = E + P + \Delta S \qquad [m/d] \tag{3}$$

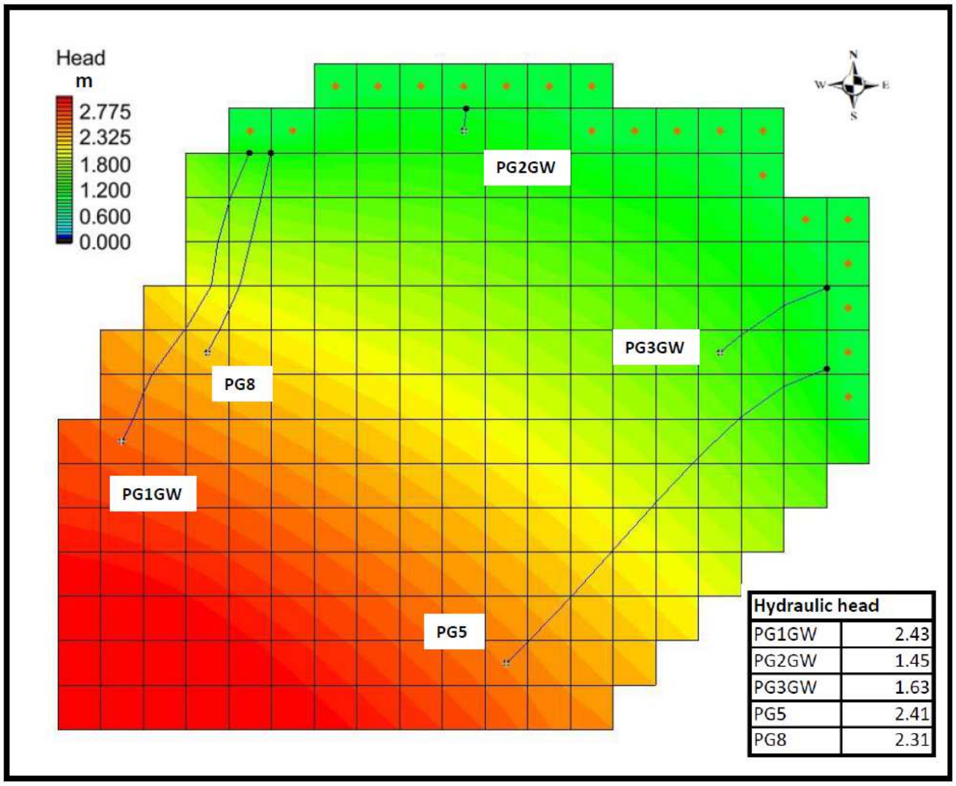
where

R_{rain} Recharge from infiltrating rain [m/d]
P Precipitation [m/d]
E Evapotranspiration [m/d]
ΔS Storage of water [m/d]

To model the groundwater recharge that derives from the area above the upper boundary in the model, different values of the upper row were tried out (R_{runoff}). The objective was to reach the known hydraulic heads in the sample points. R_{runoff} represents both the recharge from the infiltrating rain in the current cell as well as runoff from other cells not active in the simulation. In this case, R_{runoff} varied between 0.003-0.03 m/d (*APPENDIX D.2)*. MODFLOW was run and resulted in *Figure 8*.

4.3.6 MODPATH

MODPATH is an application in GMS which visualizes the dispersion of particles and its theoretical velocity. This is done by assigning particles to cells that is of interest to investigate. The program will then show the advection transport route from this location, see *Figure 8*. The pathways are calculated with help of the hydraulic heads stated in MODFLOW (Aquaveo 2019b).



Hydraulic head	
PG1GW	2.43
PG2GW	1.45
PG3GW	1.63
PG5	2.41
PG8	2.31

Figure 8: *Visualization of hydraulic heads when recharge is constant. Lines show flow paths from the sample locations. Table show hydraulic heads in steady state for each sample point, where the reference is Emån water surface which is assumed to have hydraulic head of 1m.*

4.3.7 MT3DMS

MODPATH do not take dispersion, adsorption or chemical reactions into account while investigating the particle flows. It is therefore not possible to track the contaminant plume of a contaminant in this program. Instead, the MT3DMS application is recommended (Aquaveo 2019c). Here, the advection package, dispersion package, source/Sink mixing package as well as chemical reaction package were activated. The stress period was set for 100 years. The advection was left on default settings (solution scheme: Third order TVD scheme) as well as dispersion (TRTP:0.1 TRVT: 0.01 DMCOEF:0 Longitudinal Dispersivity:10). In chemical reaction package, the sorption was set to linear isotherm (k_d-values). MT3DMS requires, other than the set ups for MODFLOW, parameters regarding density and properties of the species that are being investigated.

4.3.7.1 Bulk density

Due to the landfills heterogeneous properties, the bulk density in an MSW landfill varies considerably. Representative literature values are therefore not easily found, but according to three different studies, the bulk density varies between 350-1206 kg/m^3 in MSW landfill masses (Faitli et al. 2015, Reddy et al. 2009, and Hull, Krogmann and Strom 2005). A mean value of 778 kg/m^3 was therefore used in MT3DMS.

4.3.7.2 Species and k_d-values

To analyze the dispersion potential of selected species, their k_d-values was necessary to know. These were derived from the Swedish EPA standard values (Naturvårdsverket 2009a). For organic substances such as PAHs, the k_d-values were calculated with *Equation 4. APPENDIX D.3* shows which values that was used

$$k_d = k_{oc} \times f_{oc} \qquad [\mathrm{l/kg}] \qquad (4)$$

where:
k_{oc} organic-carbon distribution coefficient [l/kg], species specific standard values from the Swedish EPA.
f_{oc} fraction of organic carbon, where 0.02 [-] is the Swedish EPA's default value.

For the pesticide BAM, the k_d value derived from a study by Clausen, Larsen and Albrechtsen (2004), who investigated the sorption of different pesticides. The study resulted in a k_d -interval between 0.10-0.93 l/kg for BAM. The mean value of 0.42 l/kg was therefore used in MT3DMS. The MT3DMS was then run and the results from a 50-year scenario were analyzed. In the investigated samples, the concentrations were compared to current concentrations.

4.4 NEW RISK ASSESSMENT

In order to cover a broad number of aspects of risks that a contaminant poses on the area, a risk assessment covering the sensitivity and receptors, the dispersion potential, the hazardousness and level of contaminants. In the initial MIFO 1 survey, according to the information that was then available, these were all assessed to be in the highest risk zone which lead to an overall classification of the site to class 1, *very high risk*, according to *Figure 2*. After this study's more in-depth examination, some of the points could be revised and re-examined.

4.4.1 Dispersion potential

The potential of dispersion of the contaminants is taken into the risk account, such as the magnitude of the flow rate in the groundwater. The hydraulic conductivities used in this study (*APPENDIX D.2)*, corresponds to a flow rate of 0.1-10 m/year (Naturvårdsverket 1999). According to the Swedish EPA, this equals *large* dispersion potential, which was also used in the MIFO 1 survey.

4.4.2 Hazardousness of contaminants (F)

Determining the hazardousness of a substance means that the risk of being harmful to humans and the environment without any regards to the contaminant concentration is investigated. The pollutants detected in soil and groundwater are classified as *very high hazardousness* according to the Swedish EPA classification (Naturvårdsverket 1999). This is in line with the risk that was estimated in the MIFO 1-investigation.

4.4.3 Sensitivity to humans and environmental receptors (K/S)

Here, the risk related to the exposure to humans (K) as well as the identified receptors nearby (S) are assessed. The location of the site is therefore important in this aspect, as well as knowledge of the activity on and around the site. The sensitivity to humans in this study was classified as a lower *high* in accordance to the Swedish EPA classification rating. The risk on receptors (S) were set on the classification *Very large*. The reason was the proximity to Emån, National interest – Natural value area and the identified Key biotope area. K and S was placed the classification *very large* in the MIFO 1-assessment.

4.4.4 Contaminant levels

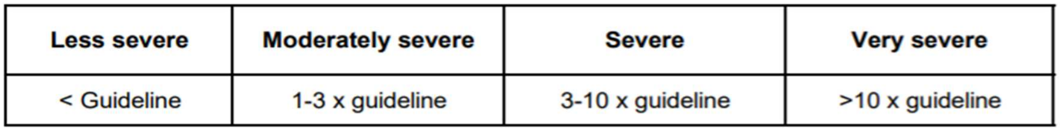
The contaminant level is of high importance in the risk assessment, where the level of the pollutant determines the effects it has on humans and the environment. To determine if a concentration is high or low, it is assessed in three parts: Assessment of permits, deviation from background value and total volume of polluted masses throughout the area. These parameters are examined for each contaminant and then weighed together into a risk classification per contaminant and media. Thereafter, an overall risk assessment can be carried out for the contaminated site in general.

4.4.4.1 Assessment of permits

When assessing the permit, the effect related to the level of contamination is estimated by comparing the concentration to guideline values where the effect is already known. In this study, the national guideline values for KM for were used for soil. For groundwater, SGU guideline classification class 2-5 was used.

Depending on whether the concentration exceeded the guideline levels or not, the concentration level was classified differently, according to the *Table 4* (Naturvårdsverket 1999). Here, the SGU guideline classification class 2-5 correspond to less severe, moderately severe, severe and very severe.

Table 4: *Classification system describing the risk of a concentration (Naturvårdsverket 1999).*

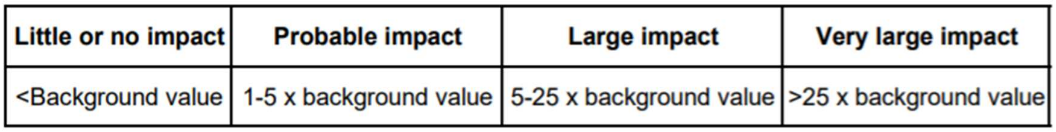


Less severe	Moderately severe	Severe	Very severe
< Guideline	1-3 x guideline	3-10 x guideline	>10 x guideline

4.4.4.2 Deviation of background levels

By comparing the contaminant concentration with its background values, a sense can be obtained over how large a proportion the site is affected by contaminant sources. This comparison was done to the contaminants with known background levels in soil and groundwater. Deviations from the background values were then classified according to *Table 5* (Naturvårdsverket 1999)

Table 5*: Classification system for soil and groundwater that describes the risk of a concentration by comparing to background levels (Naturvårdsverket 1999).*



Little or no impact	Probable impact	Large impact	Very large impact
<Background value	1-5 x background value	5-25 x background value	>25 x background value

4.4.4.3 Total volume of polluted masses

The amount and volume of contaminant in the landfill was not possible to judge due to lack of information and was therefore excluded in the risk assessment.

4.4.4.4 Overall assessment of risks

The level classifications that derived from *Assessment of permits* and *Deviation of background levels* was then compiled to a new classification risk for each contaminant (*APPENDIX E.1-E.2*). These were then compiled again into one classification to represent the overall contaminant level for each media, which is presented in the *Table 14.*

All classified risk parameters were inserted into a new risk classification diagram in *Figure 11*. The diagram visualizes which overall risk zone the site should be designated to, depending on where the risk parameters are placed. If all parameters are placed in the same risk zone, the classification will be that exact risk. If the parameters are placed in different risk zones however, an assessment over which parameters that are more important must be done. In this case, the contamination levels were assessed to be the most important parameter to consider.

A new risk assessment was done of the site for scenarios representing the site in 50 years. The same procedure was carried out as above but with the contaminant concentrations from MODFLOW representing 50 years from now. The same assumptions were made for sensitivity, protection, danger and spreading conditions like the risk assessment for the current situation. However, contamination levels for groundwater are now simulated to 50 years from the now developed MODFLOW model. As the groundwater profile in MODFLOW was divided into two layers with two different concentrations, this was taken into account in the risk assessment. The study of the pollution levels resulted in *APPENDIX E.3, Table 15* and *Figure 12*. With this, a new risk classification representing the site in a scenario 50 years from now could be set.

4.5 ASSESSMENT OF REMEDIAL ACTIVITES NEEDED

To assess whether any remediation is needed on the site, quantifiable remedial objectives were set. These were set with the aim to reach the overall goals of the area: to prevent any harm that the landfill may cause humans and the nearby environment. The quantifiable remedial objectives for the soil was set to the site-specific guidelines developed for the landfill, while the assessment for the need of groundwater remediation was based on the dispersion showing in the MODFLOW simulation.

5 RESULT

5.1 SITE-SPECIFIC GUIDELINES

The developed site-specific guidelines in soil is presented in *Table 6* and *APPENDIX A.1*. Here, the national guideline values for KM were compared to the site-specific guidelines which showed that cobalt, mercury, nickel, PAH-M, Benzene, Xylene, Aliphatics >C10-C12 and Aromatics >C16-C35 was more conservative.

***Table 6**: Site-specific guidelines compared to generic guideline values for KM (Naturvårdsverket 2009a). Prominent receptors describe which exposure pathway that determined the site-specific guideline.*

Substance	**Generic guideline values (KM)**	**Site-specific guideline values**	**Prominent protection target**
	(mg/kg DM)	*(mg/kg DM)*	
Arsenic	10	10	Background level
Barium	200	200	Protection soil env.
Lead	50	50	Intake of soil
Cadmium	0.80	0.80	Intake of vegetation
Cobalt	15	12	Intake of vegetation
Copper	80	80	Protection soil env.
Chromium	80	80	Protection soil env.
Mercury	0.25	0.12	Inhalation of vapour
Nickel	40	30	Protection of g.water
Vanadium	100	100	Protection soil env.
Zinc	250	250	Protection soil env.
PCB-7	0.008	0.008	Intake of vegetation
PAH-L	3	3	Protection soil env.
PAH-M	3.5	2	Inhalation of vapour
PAH-H	1	1	Intake of vegetation
Benzene	0.012	0.008	Protection of g.water
Ethylbenzene	10	10	Protection soil env.
Xylene	10	6	Inhalation of vapour
Aliphatics>C10-C12	100	80	Inhalation of vapour
Aliphatics >C16-C35	100	100	Protection soil env.
Aliphatics >C5-C16	100	100	Protection soil env.
Aromatics >C16-C35	10	7	Protection of g.water
Benzo(a)pyrene	-	0.08	Intake of vegetation
2.6-dichlorobenzamide	-	0.0002	Protection of g.water

5.2 XRF SCREENING ASSESSMENT

The XRF screening assessment that investigated the metal content in the soil samples did not exceed any of the national or site-specific guideline values other than for cadmium which exceeded the national or site-specific guideline values, both 0.8 mg/kg DM, see *APPENDIX B.1*. Here, the concentration of cadmium ions reached KM values as well as the site-specific guideline values for cadmium.

5.3 LAB RESULTS

All laboratory results from Eurofins can be found in *APPENDIX G*. Many contaminants were not detected and therefore not interesting for further investigations. The contaminants which were detected, can be found in the sections below (*Result 5.3.1- 5.3.2.*) as well as *APPENDIX B-C.*

5.3.1 Lab results from soil samples

No metals, except for zinc in PG1GW, were detected over the Swedish EPA guidelines for MRR (less than little risk). PG4 also showed a slight elevated zinc level as it exceeded its background value by 0.4 mg/kg DM in this sample. The high cadmium concentrations detected by the XRF was not visible in the results from Eurofins, see *Table 7.*

Table 7*. Results from metal content in soil. Guidelines regarding MRR from Swedish EPA handbook 2010:1 (Naturvårdsverket 2010), KM and MKM from Swedish EPA 2009 (Naturvårdsverket 2009a) and FA guideline from Swedish Waste Management Association (Avfall Sverige 2019). Background levels are from SGU 2007 (Naturvårdsverket 2009a) and marked with a star if exceeded. Site Specific guidelines from the Swedish EPA model (Naturvårdsverket 2019b).*

Substance	Unit	MRR	KM	MKM	FA	Back-ground levels ★	Site specific guidelines (KM)	PG1GW	PG4	PG5	PG6	PG7	PG8
Metals													
Arsenic. As	*mg/kg Dm*	**10**	**10**	**25**	**1000**	**12.1**	**10**	2.9	3.6	< 2.3	< 2.3	< 2.1	< 2.7
Barium. Ba	*mg/kg Dm*	**-**	**200**	**300**	**50000**	**-**	**200**	73	45	38	40	27	59
Cadmium. Cd	*mg/kg Dm*	**0.2**	**0.8**	**12**	**1000**	**0.16**	**0.8**	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20
Cobalt. Co	*mg/kg Dm*	**-**	**15**	**35**	**1000**	**10.1**	**12**	3.8	5.3	5.7	6.4	4.8	4.9
Chromium. Cr	*mg/kg Dm*	**40**	**80**	**150**	**10000**	**29.8**	**80**	8.6	10	8.2	9.2	8.4	7.6
Mercury. Hg	*mg/kg Dm*	**0.1**	**0.25**	**2.5**	**50**	**-**	**0.12**	0.044	0.025	0.024	0.023	0.02	0.028
Copper. Cu	*mg/kg Dm*	**40**	**80**	**200**	**2500**	**28.5**	**80**	9.4	25	5.5	13	5.2	8.7
Nickel. Ni	*mg/kg Dm*	**35**	**40**	**120**	**1000**	**22.1**	**30**	10	6.8	5.1	5.4	4	4.4
Lead. Pb	*mg/kg Dm*	**20**	**50**	**400**	**2500**	**15.6**	**50**	16 ★	10	5.9	6.7	3	9.6
Vanadium. V	*mg/kg Dm*	**-**	**100**	**200**	**10000**	**38.7**	**100**	18	21	16	19	19	16
Zinc. Zn	*mg/kg Dm*	**120**	**250**	**500**	**2500**	**60.4**	**250**	120 ★	110 ★	26	35	16	48

Figure *9* show a visualization of the metal distribution across the landfill and how nitrogen and phosphorous follow. The graph shows that PG1GW and PG4 generally has the highest metal concentrations while PG7 has the lowest metal content. Total nitrogen and phosphorus concentration show highest values at PG4, and lowest at PG7.

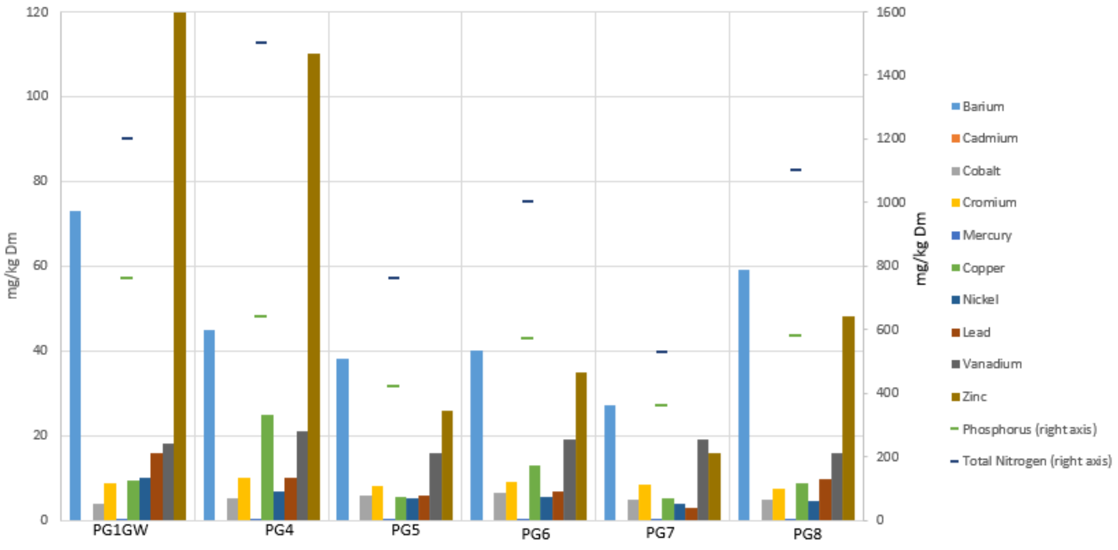
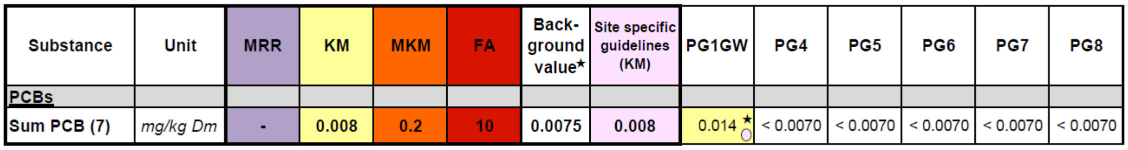


***Figure 9**: Metal distribution across the landfill, as well as total nitrogen and phosphorus concentration (mg/kg Dm, right axis).*

In PG1GW, PCB-7 was detected in the soil with a concentration exceeding the national guideline for KM, as well as site-specific guideline value, by 0.006 mg/kg DM respectively (*Table 8).*

***Table 8.** PCB concentration in soil. Guidelines regarding KM and MKM from Swedish EPA 2009 (Naturvårdsverket 2009a) and FA guideline from Swedish Waste Management Association (Avfall Sverige 2019). Background levels from Kemakta (2015), mean value of European soils. Site Specific guidelines from the Swedish EPA model (Naturvårdsverket 2019b) are marked with pink circle if exceeded.*



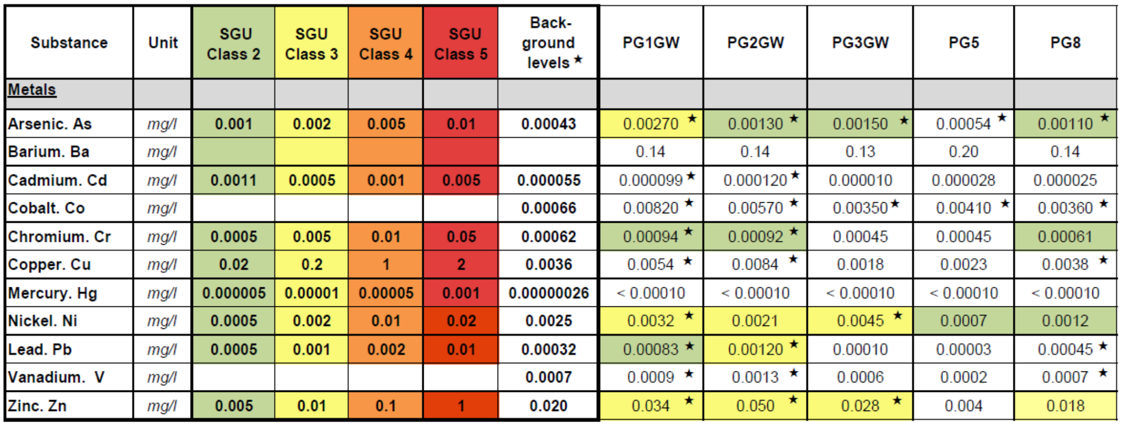
Substance	Unit	MRR	KM	MKM	FA	Back-ground value★	Site specific guidelines (KM)	PG1GW	PG4	PG5	PG6	PG7	PG8
PCBs													
Sum PCB (7)	*mg/kg Dm*	-	0.008	0.2	10	0.0075	0.008	0.014 ★ ○	< 0.0070	< 0.0070	< 0.0070	< 0.0070	< 0.0070

PG1GW also detected PAHs and aliphatics over their detection limits, which proofs that some type of contamination has occurred at that specific location (*APPENDIX B.3-B.4*), however not exceeding any guideline values. Chlorinated hydrocarbons were not detected in the soil (*APPENDIX G*).

5.3.2 Lab results from groundwater samples

In the groundwater samples, a lot of the detected metal concentrations exceeded the SGU (2013:01) classifications 2 or 3 (*Table 9*). These classifications indicate a low and a moderate dose of the substance. PG5 distinguish from other samples because of its sparse exceedance of both the SGU guidelines, as well as exceedance of background levels, while PG1GW and PG2GW have overall the highest metal concentrations, for example, they both have three metals who exceed SGU classification 3. These sample points also exceed the metal backgrounds levels more than the other samples. The background levels for cobalt and arsenic are exceeded in every sample. No mercury was detected in any of the groundwater samples.

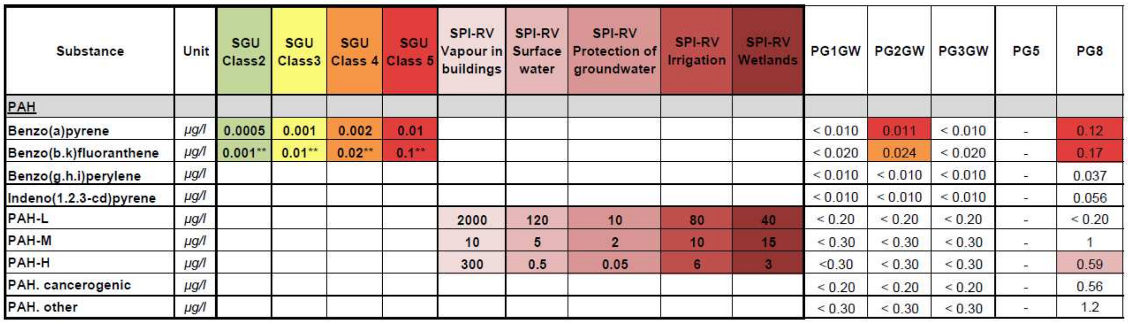
***Table 9:** Metal concentrations detected in groundwater (mg/l). The SGU guidelines Class 2-5 are for filtered metal samples. These, along with background levels are derived from the SGU-report 2013:01. Arsenic, chromium, nickel, lead and zinc were found in the largest quantities.*



Substance	Unit	SGU Class 2	SGU Class 3	SGU Class 4	SGU Class 5	Back-ground levels ★	PG1GW	PG2GW	PG3GW	PG5	PG8
Metals											
Arsenic. As	*mg/l*	0.001	0.002	0.005	0.01	0.00043	0.00270 ★	0.00130 ★	0.00150 ★	0.00054 ★	0.00110 ★
Barium. Ba	*mg/l*						0.14	0.14	0.13	0.20	0.14
Cadmium. Cd	*mg/l*	0.0011	0.0005	0.001	0.005	0.000055	0.000099 ★	0.000120 ★	0.000010	0.000028	0.000025
Cobalt. Co	*mg/l*					0.00066	0.00820 ★	0.00570 ★	0.00350 ★	0.00410 ★	0.00360 ★
Chromium. Cr	*mg/l*	0.0005	0.005	0.01	0.05	0.00062	0.00094 ★	0.00092 ★	0.00045	0.00045	0.00061
Copper. Cu	*mg/l*	0.02	0.2	1	2	0.0036	0.0054 ★	0.0084 ★	0.0018	0.0023	0.0038 ★
Mercury. Hg	*mg/l*	0.000005	0.00001	0.00005	0.001	0.00000026	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Nickel. Ni	*mg/l*	0.0005	0.002	0.01	0.02	0.0025	0.0032 ★	0.0021	0.0045 ★	0.0007	0.0012
Lead. Pb	*mg/l*	0.0005	0.001	0.002	0.01	0.00032	0.00083 ★	0.00120 ★	0.00010	0.00003	0.00045 ★
Vanadium. V	*mg/l*					0.0007	0.0009 ★	0.0013 ★	0.0006	0.0002	0.0007 ★
Zinc. Zn	*mg/l*	0.005	0.01	0.1	1	0.020	0.034 ★	0.050 ★	0.028 ★	0.004	0.018

PAH was only detected in PG2GW and PG8, where the concentration was significantly higher in PG8, *(Table 10)*. Benzo(a)pyrene was classified as a class 5 for both samples, hence the water is not drinkable in these locations. It also exceeded the site-specific guidelines. Benzo(b,k)fluoranthene, Benzo(g,h,i)perylene and Indeno(1,2,3-cd)pyrene are also elevated, especially in PG8. PG8 also shows exceeding values for SPI's limit values for protection of groundwater and surface water due to PAH-H (Svenska Petroleum Institutet 2010). Worth noticing is the difference in sampling methods between the two samples.

Table 10*: PAH concentrations in groundwater samples. PG2GW and PG8 detected exceeding PAH concentrations. The SGU guidelines derives from SGU-report 2013:01, the SPI-RV from SPI report published 2010. ** indicate that the guideline value applies to the sum of benzo(b,k)fluoranthene, benzo(ghi)perylene and indeno(123-cd)pyrene.*



Substance	Unit	SGU Class2	SGU Class3	SGU Class 4	SGU Class 5	SPI-RV Vapour in buildings	SPI-RV Surface water	SPI-RV Protection of groundwater	SPI-RV Irrigation	SPI-RV Wetlands	PG1GW	PG2GW	PG3GW	PG5	PG8
PAH															
Benzo(a)pyrene	*µg/l*	0.0005	0.001	0.002	0.01						< 0.010	0.011	< 0.010	-	0.12
Benzo(b.k)fluoranthene	*µg/l*	0.001**	0.01**	0.02**	0.1**						< 0.020	0.024	< 0.020	-	0.17
Benzo(g.h.i)perylene	*µg/l*										< 0.010	< 0.010	< 0.010	-	0.037
Indeno(1.2.3-cd)pyrene	*µg/l*										< 0.010	< 0.010	< 0.010	-	0.056
PAH-L	*µg/l*					2000	120	10	80	40	< 0.20	< 0.20	< 0.20	-	< 0.20
PAH-M	*µg/l*					10	5	2	10	15	< 0.30	< 0.30	< 0.30	-	1
PAH-H	*µg/l*					300	0.5	0.05	6	3	<0.30	< 0.30	< 0.30	-	0.59
PAH. cancerogenic	*µg/l*										< 0.20	< 0.20	< 0.20	-	0.56
PAH. other	*µg/l*										< 0.30	< 0.30	< 0.30	-	1.2

Pesticides were analyzed in PG1GW and PG2GW and both samples detected the pesticide 2,6-dichlorobenzamide (BAM) *(Table 11)*. According to SGU (2013:01) guidelines, the BAM concentration reached class 3, significant content and thereby impact, in sample PG1GW, and a high content and strong impact in PG2GW (class 4). The national guideline of allowed rate in drinking water (0.1 µg/l) was however, not exceeded. Neither did the site-specific guidelines for BAM. No other pesticides were detected, which was the same for petroleum's and PCBs (*APPENDIX H)*.

Table 11: *Guidelines according to SGU-report 2013:01. Here, only PG1GW and PG2GW were analyzed for pesticides and both detected exceeding classification values.*

Substance	Unit	SGU Class 2	SGU Class 3	SGU Class 4	SGU Class 5	PG1GW	PG2GW	PG3GW	PG5	PG8
Pesticides										
2,6-dichlorobenzamide	µg/l	0.01	0.025	0.05	0.1	0.04	0.06	-	-	-

5.4 CONCENTRATIONS 50 YEARS FROM NOW

The MODFLOW and MT3DMS simulations were done with a selection of substances and were analyzed in a 50-year time scale. The results can be seen in *Table 12* and *Table 13*. Generally, a lot of the contaminants are still present in the groundwater, even 50 years from now. It is also noticed that layer 2, with a low hydraulic conductivity, have leached less contaminants than layer 1, with a higher hydraulic conductivity. In layer 1, zinc is the only contaminant that is still classified as class 3, which indicates a moderate dose, while for layer 2, all the contaminants which was classified as 3 are remaining after 50 years. The mean percentage of contaminants remaining after 50 years compared to the concentration during day 1 can be found in the last column in each table. Here, it shows that lead, and zinc and benzo(a)pyrene remains in the groundwater to a large extent, compared to chromium, arsenic and BAM. This is in line with the substances' k_d-values.

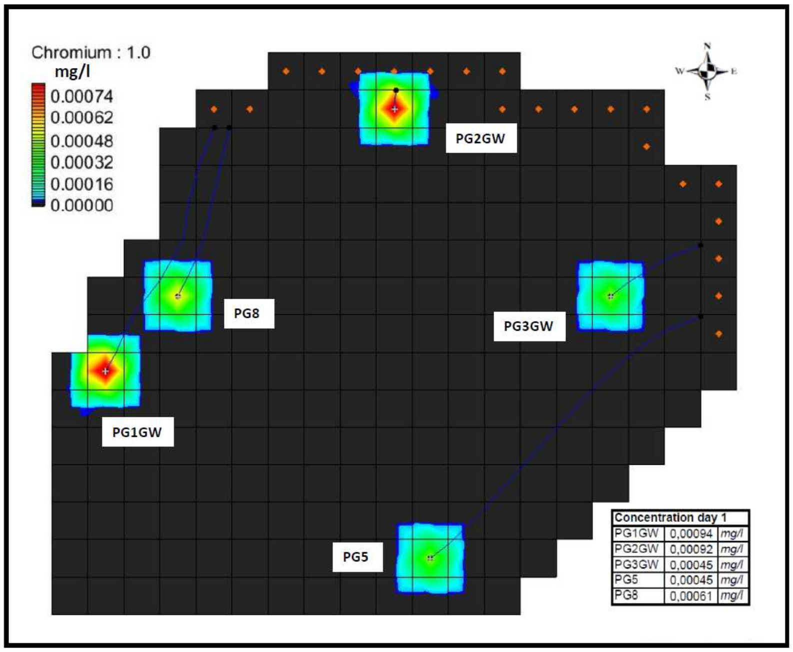
Table 12: *Simulated concentrations in each sample point in layer 1, 50 years from now. The remaining content in groundwater compared to day 1 is presented in the last column. For instance, it is 9.82% arsenic left in the upper groundwater layer compared to day one.*

Substance	Unit	SGU Class 2	SGU Class 3	SGU Class 4	SGU Class 5	Back-ground levels⋆	PG1GW	PG2GW	PG3GW	PG5	PG8	% remain after 50 yrs
Metals												
Arsenic. As	mg/l	0.001	0.002	0.005	0.01	0.00043	0.00021	0.00013	0.00010	0.00004	0.00019	9.82
Chromium. Cr	mg/l	0.0005	0.005	0.01	0.05	0.00062	2E-05	3E-05	2E-05	1E-05	2E-05	3.02
Nickel. Ni	mg/l	0.0005	0.002	0.01	0.02	0.0025	0.0007	0.0004	0.0008	0.0002	0.0002	21.96
Lead. Pb	mg/l	0.0005	0.001	0.002	0.01	0.00032	0.00058 ⋆	0.00072 ⋆	0.00006	0.00003	0.00029	66.88
Zinc. Zn	mg/l	0.005	0.01	0.1	1	0.02	0.0133	0.0163	0.0089	0.0020	0.0060	37.25
Pesticides												
2.6-dichlorobenzamide	µg/l	0.01	0.025	0.05	0.1	-	5E-06	8E-08	-	-	-	0.0057
PAH												
Benzo(a)pyrene	µg/l	0.0005	0.001	0.002	0.01	-	< 0.010	0.0101	< 0.010	-	0.1125	92.96

Table 13: *Simulated concentrations in each sample point in layer 2, 50 years from now. The remaining content in groundwater compared to day 1 is presented in the last column. For instance, it is 83.09% arsenic left in the lower groundwater layer compared to day one.*

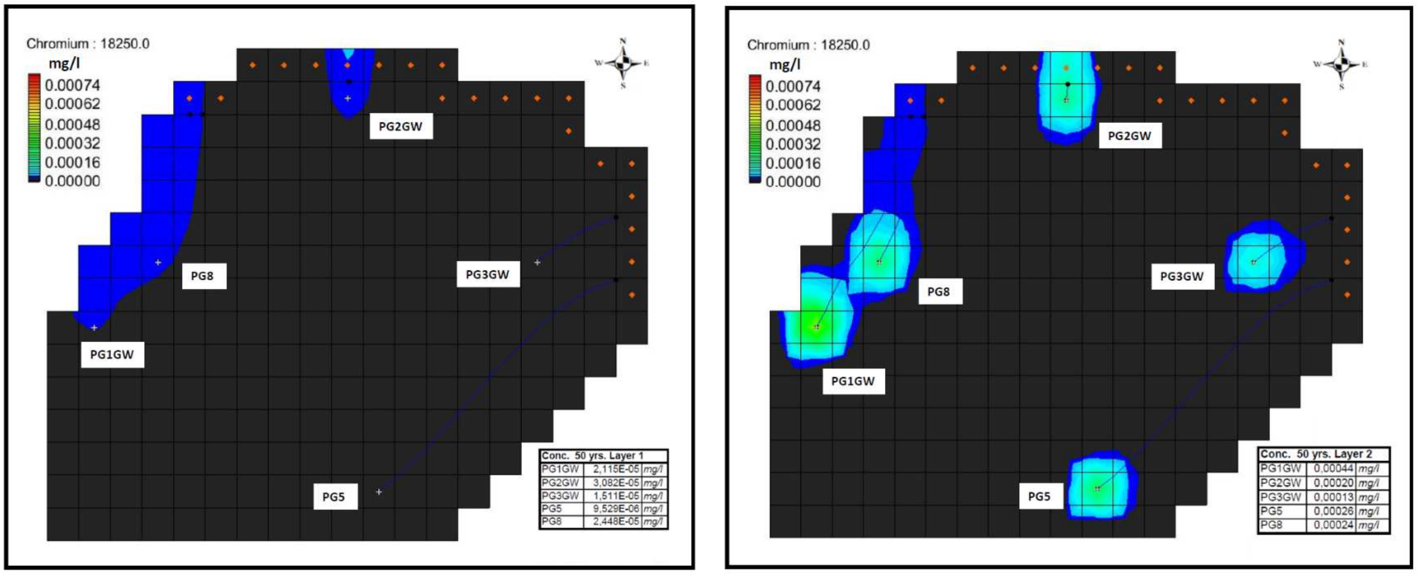
Substance	*Unit*	SGU Class 2	SGU Class 3	SGU Class 4	SGU Class 5	Back-ground levels⋆	PG1GW	PG2GW	PG3GW	PG5	PG8	% remain after 50 yrs
Metals												
Arsenic. As	mg/l	0.001	0.002	0.005	0.01	0.00043	0.00234 ⋆	0.00097 ⋆	0.00119 ⋆	0.00049 ⋆	0.00092 ⋆	83.09
Chromium. Cr	mg/l	0.0005	0.005	0.01	0.05	0.00062	0.00044	0.00020	0.00013	0.00026	0.00024	38.94
Nickel. Ni	mg/l	0.0005	0.002	0.01	0.02	0.0025	0.0031 ⋆	0.0020	0.0043 ⋆	0.0006	0.0011	95.74
Lead. Pb	mg/l	0.0005	0.001	0.002	0.01	0.00032	0.00083 ⋆	0.00119 ⋆	0.00009	0.00003	0.00045 ⋆	99.47
Zinc. Zn	mg/l	0.005	0.01	0.1	1	0.02	0.0335 ⋆	0.0485 ⋆	0.0274 ⋆	0.0040	0.0177	98.07
Pesticides												
2.6-dichlorobenzamide	µg/l	0.01	0.025	0.05	0.1	-	4E-05	1E-07	-	-	-	0.045
PAH												
Benzo(a)pyrene	µg/l	0.0005	0.001	0.002	0.01	-	< 0.010	0.0110	< 0.010	-	0.1199	99.93

The results of the metal that showed the least concentration (chromium) after 50 years are visualized in MT3DMS maps in *Figure 10*.



Concentration day 1		
PG1GW	0,00094	*mg/l*
PG2GW	0,00092	*mg/l*
PG3GW	0,00045	*mg/l*
PG5	0,00045	*mg/l*
PG8	0,00061	*mg/l*

Figure10 (a).



Conc. 50 yrs. Layer 1		
PG1GW	2,115E-05	*mg/l*
PG2GW	3,082E-05	*mg/l*
PG3GW	1,511E-05	*mg/l*
PG5	9,529E-06	*mg/l*
PG8	2,448E-05	*mg/l*

Conc. 50 yrs. Layer 2		
PG1GW	0,00044	*mg/l*
PG2GW	0,00020	*mg/l*
PG3GW	0,00013	*mg/l*
PG5	0,00026	*mg/l*
PG8	0,00024	*mg/l*

Figure 10 (b)

Figure 10 (c)

Figure 10. *GMS results of chromium. Concentration day 1 (a) (both layers) and after 50 years in layer 1 (b) and layer 2 (c). Here, it is visible that there are more contaminants still left in the groundwater in the lower layer (10 (c)). Also, the plumes are moving towards, and reaching the river Emån.*

5.5 NEW RISK CLASSIFICATION

The contaminant concentrations detected in the field study was classified in order to implement the result in a new risk assessment for the eastern part of the site. The level of contaminants resulted *Table 14.*

Table 14*: Assessed overall contamination content in soil and groundwater based on comparison to the national guidelines values as well as their background levels.*

Classification level of contaminant	
Soil	Low
Groundwater	Upper moderate

The contaminant level as well as the other risk parameters were inserted in the diagram on locations which represents the risk classifications, see *Figure 11.*

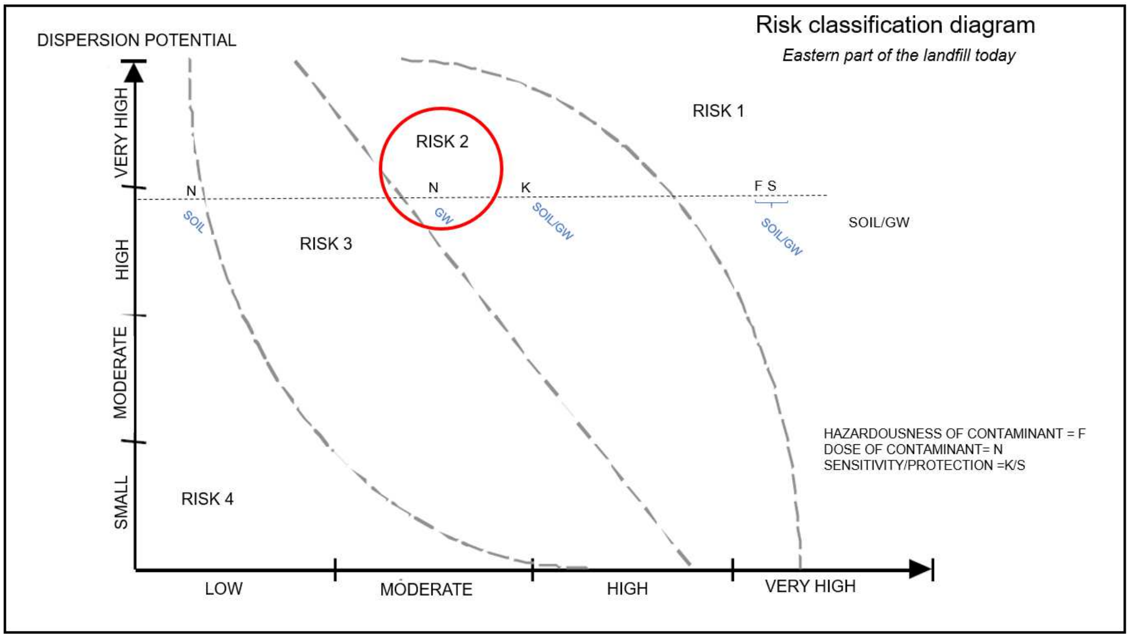


Figure 11: *Risk classification of the eastern part of the landfill.*

By analyzing the diagram, the new risk classification for the site was assessed to a risk 2.

A risk assessment was conducted for a scenario representing the site 50 years from now. All risk parameters, other than contaminant levels in groundwater, were assumed to remain in the same risk classification as the day 1 scenario. The overall levels of contaminants in the groundwater (layer 1 and 2) resulted in *Table 15.*

Table 15: *Assessed overall contamination level 50 years from now. Based on comparison the simulated concentrations in MODFLOW to the site-specific guidelines as well as their background levels. The soil classification was assumed to be constant throughout the 50 years*.

Classification level of contaminant 50 years from now	
Soil	Low
Groundwater Layer 1	Low
Groundwater Layer 2	Moderate

The contaminant level from *Table 15* as well as the other risk parameters were inserted in the diagram on locations which represents the risk classifications, see *Figure 12*.

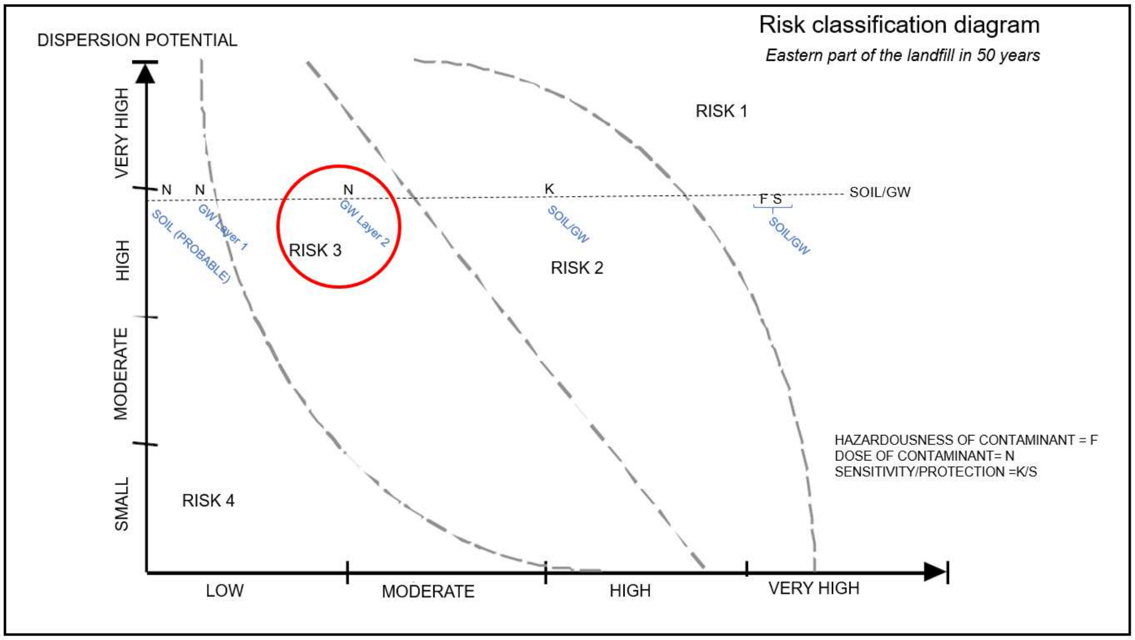


Figure 12: *Risk classification of the eastern part of the landfill 50 years from now.*

By analyzing the diagram, the new risk classification for the site was assessed to a risk 3.

5.6 QUANTIFIABLE REMEDIAL OBJECTIVES

Quantifiable remedial objectives indicate the need of remediation actions due to the contamination risk. The remedial objectives set for *Rösaberg inerta massor* was that the contaminant levels in the soil should not exceed the site-specific guidelines. If there are no exceedance, no remediation is needed.

According to *Table 16*, where the site-specific guidelines (=quantifiable remedial objectives) as well as the highest measured concentration in soil is presented, all contaminants meet the remedial objectives, except for PCB-7.

Table 16: *Quantifiable remedial objectives in soil.*

Substance	Quantifiable Remedial Objectives Conc. in soil	Highest measured conc. in soil
	mg/kg	*mg/kg*
Arsenic	**10**	3.6
Barium	**200**	73
Lead	**50**	16
Cadmium	**0.8**	<0.2
Cobalt	**12**	5.7
Copper	**80**	25
Chromium	**80**	10
Mercury	**0.12**	0.044
Nickel	**30**	10
Vanadium	**100**	21
Zinc	**250**	120
PCB-7	**0.008**	0.014
PAH-L	**3**	0.23
PAH-M	**2**	0.092
PAH-H	**1**	0.13
Benzene	**0.008**	<0.0035
Ethylbenzene	**10**	<0.1
Xylene	**6**	<0.1
Aliphatics>C10-C12	**80**	6
Aliphatics >C16-C35	**100**	34
Aliphatics >C5-C16	**100**	13
Aromatics >C16-C35	**7**	0.77
Benzo(a)pyrene	**0.08**	<0.03
2.6-dichlorobenzamide	**0.0002**	0

6 DISCUSSION

6.1 FIELD INVESTIGATION

6.1.1 Selection of trial pits locations and lab analyzes

The selected method for the field investigation was the assessment-based approach, which is heavily dependent on sufficient background information in order to make reliable decisions that mirrors the true properties of the site (Norrman et al. 2009). The disadvantage of assessment-based sampling is that no statistical analysis can be performed on the results since the locations are not picked randomly (Naturvårdsverket 1994). Figure 13 show locations the sample points.

Since the oriented assessment MIFO 1 had given *Rösaberg inerta massor* a risk level 1, the initial belief was that the landfill would contain large amounts of household waste. The plan was therefore to analyze each collected sample for a variety of different contaminants, such as metals (incl. Hg), BTEX, aliphatic compounds, aromatic compounds, PAH16, PCB 7, and chlorinated solvents. To stay in the financial budget that AFRY had set for the project, it was not reasonable to analyze all contaminants in every trial pit. A selection of lab analyses was therefore prioritized based on visual assessment of each trial pit and with prior information of the site and its deposited stages.

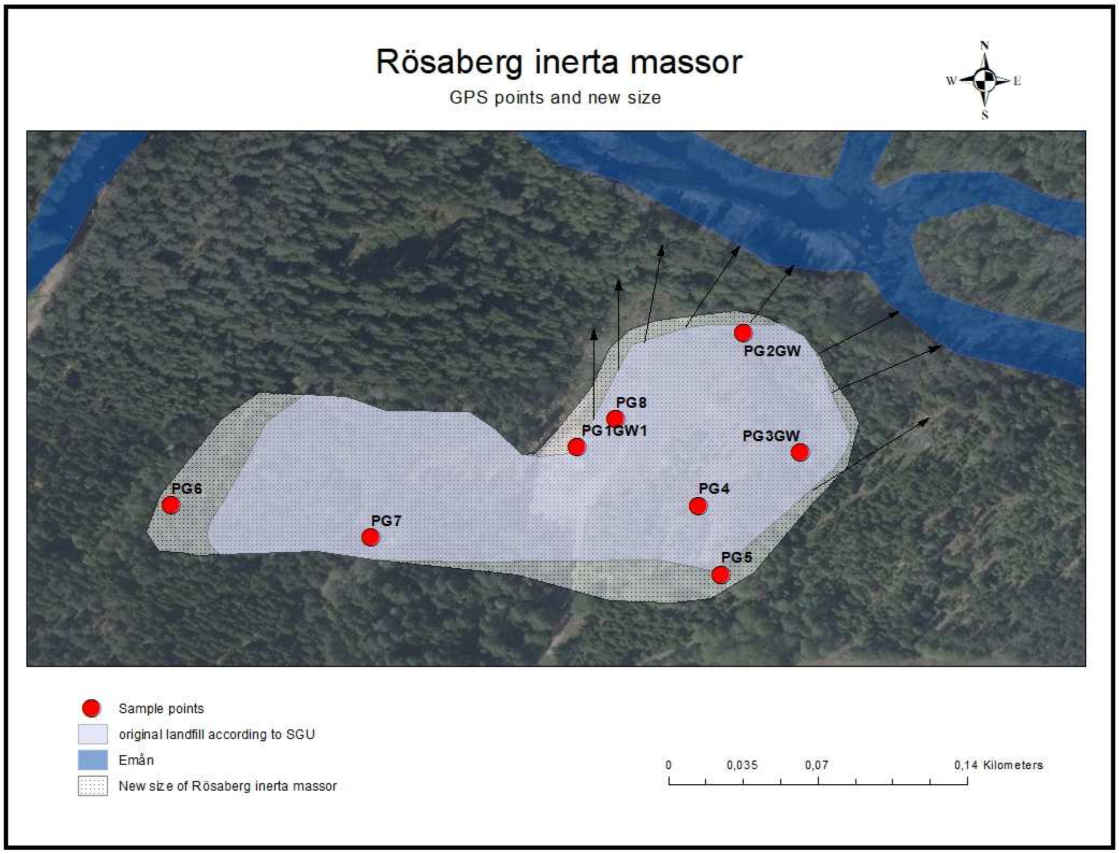


Figure 13: *Locations of sample points measured with GPS. The map visualizes the new size of the landfill as well as its old estimated size. Soil type layer showing original landfill size and river Emån: Jordarter 1:25 000-1:100 0000. ©Sveriges Geologiska Undersökning (2014). Background map: Ortofoto ©Sveriges Geologiska Undersökning (2019). Arrows show presumed groundwater and runoff flow path.*

The first trial pit (PG1GW) showed visual household waste at an approximate depth of 4 m and thus, samples were collected with regards to all suspected contaminants. After analyzing the lab results, it showed that it was this location that was the most polluted in terms of soil (*Table 7-8*). In trial pits 2 and 3 (PG2GW and PG3GW), no household waste was visible, but showed a large amount of big, ungraded crushed rocks and asphalt material. Nor did the PID assessment give any indications that volatile substances were present *(Table 2).* Hence, the judgement was made that soil analysis could be excluded. Partly because groundwater wells would be placed and analyzed regarding the infiltrated groundwater anyway. The locations of monitoring wells were selected with the aim to confirm the assumed groundwater flow direction from the landfill towards the river Emån.

Sample pit 4 (PG4), located at the uppermost top of the landfill (stage 3), showed no visible contamination or odor. The soil was dark and easily excavated and the area was well vegetated. This led to the belief that the masses could be derived from wastewater treatment plants, and to confirm this, analyses regarding nutrients were especially interesting to analyze. Similar evaluation was made for sample pit 7 (PG7). The lab result from PG4 did show high phosphorus and nitrogen contents relative to the other trial pits (*APPENDIX B.1* and *APPENDIX C.1*), but not as big to suspect it to derive from wastewater.

For sample pit 5 (PG5), PAH16 was analyzed due to the characteristic colour and odor of the excavated soil. Also, the water surface on the bottom of the pit had signs of some sort of oil pollution. Therefore, a water sample was conducted via the excavation shovel, and sent for analysis of oils and metals. The analysis showed no exceeding levels, other than mercury values that exceeded the SGU class 2 (*Table 9-11*).

The initial idea was to place a groundwater monitoring well in PG6 because of its location to the river Emån on the western part of the landfill. However, the excavation showed a very high content of large ungraded crushed rocks which lead to that the excavator failed to reach the depth of the groundwater. The metal content was investigated in in this trial pit, as the masses appeared to come from some sort of mining waste. The lab results did not show any exceeding metal concentrations (*Table 7*), however.

Sample pit 8 (PG8) was presumed to have similar contaminants as PG1GW because of their proximity (approximately 20 meters apart, *Figure 13*). Even though no household waste was found in the eighth sample pit, it was still of interest to perform a full soil analysis alike sample PG1GW, if not least to confirm the delimitation of the first trial pits contaminants. The lab results of the soil analyses did confirm a delimitation of household contaminations, since no exceeding concentrations in the soil was shown in PG8 (*Table 7-8* and *APPENDIX B.3-B.4)*. A water sample was collected from the bottom of the trial pit. Here, PAH16 was included in the analysis since asphalt waste had been detected during the excavation. The lab result did show high concentrations of PAHs as well as some metals, such as zinc (*Table 9-10*). Conclusion is that the household waste found in PG1GW is delimited to not be as wide as 20 m east.

6.2 UNCERTAINTIES IN RESULTS

For P4-P8, sub-samples were taken throughout the mound of soil in the pursuit to get a representation of the whole soil profile. Even if effort was made to prevent it, there is still a statistical chance that soil was collected from one depth only, or from depths where no contaminants were present and thereby gave misleading results. This method also assumes constant concentrations throughout the whole profile, which restricts the spatial understanding of the pollution of the site. The assumption may lead to under- or overestimations of the properties of the pit which in turn can cause errors in assessing the overall risks in the landfill. The major challenge in obtaining one single value to represent the true properties of the profile is therefore the landfills heterogeneity. To overcome this, a high number of sub-samples is recommended (Larsson 2012) and would have improved the certainty in this study.

In PG5 and PG8, infiltrating water was collected from the excavation shovel. What is important to remember is that this water may be groundwater mixed with leachate, and that the water may be affected by the agitation of the soil due to the excavators digging. This was something that Eurofins was keen to inform and warn about. The results from these samples were however treated as groundwater in this study. Since the other groundwater samples PG1GW-PG3GW were collected in a different way, deviations in the results may occur. There were no clear differences in the metal concentration between the two methods. However, the nitrogen and phosphorus contents were found to be significantly higher in PG5 and PG8 than in PG1GW-PG3GW. The water had a brownish colour when it was collected, which indicates that it contains a lot of organic matter and particles which may be the answer to the high nutrient concentration. The same pattern was found for PAHs with high molecular weight (PAH-Hs), where for instance the concentration of Benzo(a)pyrene was ten times higher in PG8 than in PG1GW. The reason for this may be that leachate from PG1GW, as well as other point sources in the landfill not detected in this study, reached the location of PG8, since there were no signs of PAHs in the soil results of PG8. The suspended water may also have contained colloids with PAHs. This is in line with the theory that contaminants with a low solubility like PAH-H have a higher affinity to bind with colloids (Naturvårdsverket 2009a).

What is also worth noticing is that the measurement uncertainty of the lab results can reach up to 40 % according to Eurofins (Eurofins n.d.). A solution to this is to add more sample points across the landfill. This would not only cover a larger part of the landfill but would also give a better foundation to do statistical calculations and statements of the contamination situation. It would also make it more likely find and exclude outliers that may have occurred due to method errors or laboratory uncertainties. Since a landfill is heterogeneous in its nature (Rihm 2011), outliers will always be hard to detect.

6.3 DEGRADATION LEVEL

Since the landfill closed approximately 40 years ago, the degradation of the masses should generally be in the third phase, the methanogenic phase, according to the timeline of the landfill's life cycle. The pH was found to be between 5.6-6.2 in the soil and 5.9-6.9 in the groundwater (*APPENDIX B.1* and *APPENDIX C.1*) which is a neutral pH. This is in accordance to the theory of methanogenic phase (*Table 1* states the normal pH in untreated leachate in methanogenic landfills). This phase should also have less leachate than the earlier phases. The phosphorus levels in PG1GW-PG3GW were also in accordance with the levels common in a methanogenic phase. PG5 and PG8 had significantly higher levels than the others, which is explained by the difference in methodology. For the nitrogen levels on the other hand, PG5 and PG8 were the ones in the interval normal for the methanogenic phase. The metal concentrations were generally also in line with commonly found concentrations in methanogenic phase landfills. Some trial pits, especially PG1GW and PG4, had an odor of sulfur while digging in the soils. Since the masses of the landfill were deposited at different times and with different content and properties, deviations in degradation across the landfill is however very likely to occur.

6.4 SITE SPECIFIC GUIDELINE VALUES AND MODFLOW SIMULATIONS

The MT3DMS simulation indicated that the contaminant plume will be directed towards the river Emån. Contaminants deriving from PG1GW, PG2GW and PG8 reached the riverbank from the north side of the landfill while PG3GW and PG5 from the east side of the landfill. By analyzing the plumes in a 50-year scenario, it is clear that the majority of each contaminants have reached the river, even if it is not from every sample point (for instance lead, only contaminants from PG2GW reaches the river Emån). Since the landfill closed about 40 years ago it is very likely that the Emån is polluted by contaminants from the landfill. Also considering that it is very likely that more contaminant sources than the ones found in this study that contribute to the pollution, as well as the contaminant levels should have been significantly higher 40 years ago. However, whether these contaminants are causing negative effects on Emåns' water quality or wildlife is up to further investigations to analyze. Considering the overall high discharge of Emån, it is likely that the contaminants are diluted which minimizes the risks of negative effects.

In the modeling, a few assumptions were made in order to simplify the problem. For instance, while determining the site-specific guidelines, the depth of the contaminants was assumed to start 0.1 m below the surface. It was chosen as a precautionary measure since the chosen soil sample methodology required the assumption that the concentrations found was constant throughout the whole profile. In reality, this is most likely not the case, and all contaminants may as well be 4 m down as in PG1GW, but for the sake of obtaining a scenario of a worst case, the contaminant depth was set close to the surface.

In GMS, many of the parameters inserted was obtained from literature, which naturally gives a skewed representation of the true properties of the landfill, such as bulk density. For instance, a mean value of bulk density used in other studies (Faitli et al. 2015, Reddy et al. 2009, and Hull, Krogmann and Strom 2005) was used. Another approach would be to use the highest of lowest densities, to reveal more extreme conditions. The same was for precipitation, since a mean of a 30-year rainfall was used. No extreme weather events are therefore considered in the model. In MT3DMS, the contaminant concentrations were inserted in the corresponding cell as starting concentrations. These could vary in time, in other words, they were not set as sources of contaminants. It is likely however, that a point source is currently active in the adjacent landfill and provides the rest of the landfill a constant inflow of contamination. If that is the case, the MT3DMS simulation which estimates the concentration rate in 50 years will not be accurate.

6.5 RISK CLASSIFICATION

In the initial MIFO 1 survey, the risk was estimated to meet the risk classification 1. With the new information that this study entails, some of the points could be revised and re-examined. The classification of contamination level, resulted in *Table 14* and *Table 15* was determined for groundwater and soil, and based on *APPENDIX E.1 – E.3*. The general classification was done with the aim to select the classification which included most contaminants, but still take the contaminants with larger levels into account. For instance, groundwater had the most contaminants in the risk level *moderate*, except for PAHs and BAM, which were classified in the risk level *very high*. The risk was therefore set as *upper moderate*. Here, the knowledge that P8 was sampled with an alternative (and not as certain) methodology was weighed in. With the new risk classification diagrams *Figure 11* and *Figure 12*, a risk assessment was done. For the risk that the landfill poses today, it was set to a risk 2 with the rational to take the contaminant level in the first room, which in this case was groundwater. The contamination level is in this study the limiting factor, since no risk would occur with no or small doses of the contaminants.

A risk 3 was set for the 50-year-from-now scenario for the landfill. Again, to construct a worst-case scenario, the highest contamination levels were considered which was in layer 2 of the groundwater. Reason to why a risk 3 is suitable to the landfill in the 50 year scenario is that the contaminant levels indicate that only a small percentage of the contaminant levels will remain in the upper groundwater level, while a larger percentage will still remain in the lower one, mainly due to differences in hydraulic conductivity. This means that the exposure sensitivity to humans will not be as high, since the contaminants will be further down in the ground. In the lower layer, the dispersion potential will get lower, since the conductivity of layer 2 is set as lower than layer 1. This in turn will also imply a smaller risk to the adjacent protected objects.

In GMS, as well as while determining the risk classification and developing the site-specific guidelines, the study was limited to the eastern part of the landfill. The reason for this is that more samples were taken in this area and more prior information of this area was provided. Also, from the site investigation as well as from the sample results it was judged that the eastern part was probably more contaminated, and that the risk concerning the western part would be less than the eastern. By following the risk classification given the eastern part, the western part will most likely also be protected.

6.6 IS THERE A NEED FOR REMEDIATION ACTIONS?

According to *Table 16*, all contaminants but PCB-7 met the quantifiable remedial objectives set for the soil in *Rösaberg inerta massor*. The level of PCB-7 was 0.014 mg/kg DM, while the site-specific level was 0.008 mg/kg DM. Also, PCBs were only found in one sample location, while the other sample points did not detect any PCBs. No PCB was found in any of the groundwater samples which means that the only exposure pathways of PCB-7 is through inhalation of dust or intake of soil. Since the site is not frequently visited by humans, the risk related to humans will be very small. No remediation of the soil is therefore assessed not necessary.

When it comes to any remediation related to groundwater it may be recommended if there are plans of extracting of drinking water in the close area, which in this minute, there are none.

Most of the contaminants in the groundwater reached SGU classification 3 at the most, other than PAH-Hs which reached a class 5 and is thus inhibiting the groundwater from being used as drinking water. Since the dispersion of all contaminants showed to reach the river Emån, it could also be discussed whether this will cause any negative effects Emåns' water quality or wildlife. Further investigations should therefore be done to rule out that *Rösaberg inerta massor* are in fact affecting the river negatively, and a remediation could then be necessary.

6.7 FURTHER INVESTIGATIONS AND RECOMMENDATIONS

This study concluded a new MIFO risk classification of a risk 2, but further investigations may be necessary before changing the risk, alternatively a MIFO 2. It should be investigated whether the contaminants in the groundwater are affecting the river Emån negatively.

Suggested further investigation are:

- Sediment sampling as well as water sampling in river Emån to establish the dispersion of contaminants deriving from *Rösaberg inerta massor*
- Investigate the levels of leachate
- More soil samples on the western wing of the landfill

It is up to the municipality as a supervisory authority to decide if the risk classification should be changed. The landfill will however, regardless of change in risk classification, still be included the EBH listing over contaminated areas according to the County Administrative Board of Jönköping County[3]. From the 50-year scenario, it was seen that a lot of the contaminants will have decreased. Since the recovery rate is relatively quick, as well as the exposure risk to humans is low, the management recommended for this site is natural remediation, which allows the site to recover itself by degradation and dispersion without any anthropogenic help. Since it was shown that groundwater was more polluted than the soil, it can be profitable to control the degradation development by taking groundwater samples via the monitoring wells to control that the development curve is going the right way.

There have been discussions to investigate the possibility to initiate an urban mining project, where the landfill masses can be used for other purposes. Reusing these masses would not only mean a financial benefit to the region but also support sustainability.

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7 CONCLUSION

This study showed that the landfill does not contain as much household waste as originally believed. Household waste was only visually detected at one part (PG1GW) of what is named as stage 1 of the landfills eastern side but proved to be delimited at least 20 m east of it (PG8). Lab results of soil and groundwater showed that not many contaminant levels in the landfill reached high concentrations. Some contaminants that was suspected in the beginning of the study were not even detected, such as chlorinated hydrocarbons in the soil and petroleum's in the groundwater. Generally, there were more exceeding contaminants in the groundwater than in the soil, and it was only in the groundwater that levels worth noticing was found, such as PAH-Hs and 2,6-dichlorobenzamide.

The GMS assessment assessed a 50-year scenario of the eastern part of the landfill and showed that a lot of the contaminants in the upper groundwater layer will be dispersed, while the concentrations remained relatively constant in the lower groundwater layer.

A risk assessment using the information obtained from the study gave indications that the risk is lower than initially expected. The risk was in this study set to a risk 2 with a conservative approach due to some high levels of PAHs and pesticides in the groundwater. The risk was estimated to a risk 3 in 50 years.

No remediation action to the soil is assessed to be necessary, since the contamination levels reaches the remediation objectives and therefore the remediation goals. The groundwater is not in need of remediation if it is not extracted for drinking water. It should be investigated whether the contaminants in the groundwater are affecting the river Emån negatively, which needs to be done before ruling out the necessity for remediating the groundwater.

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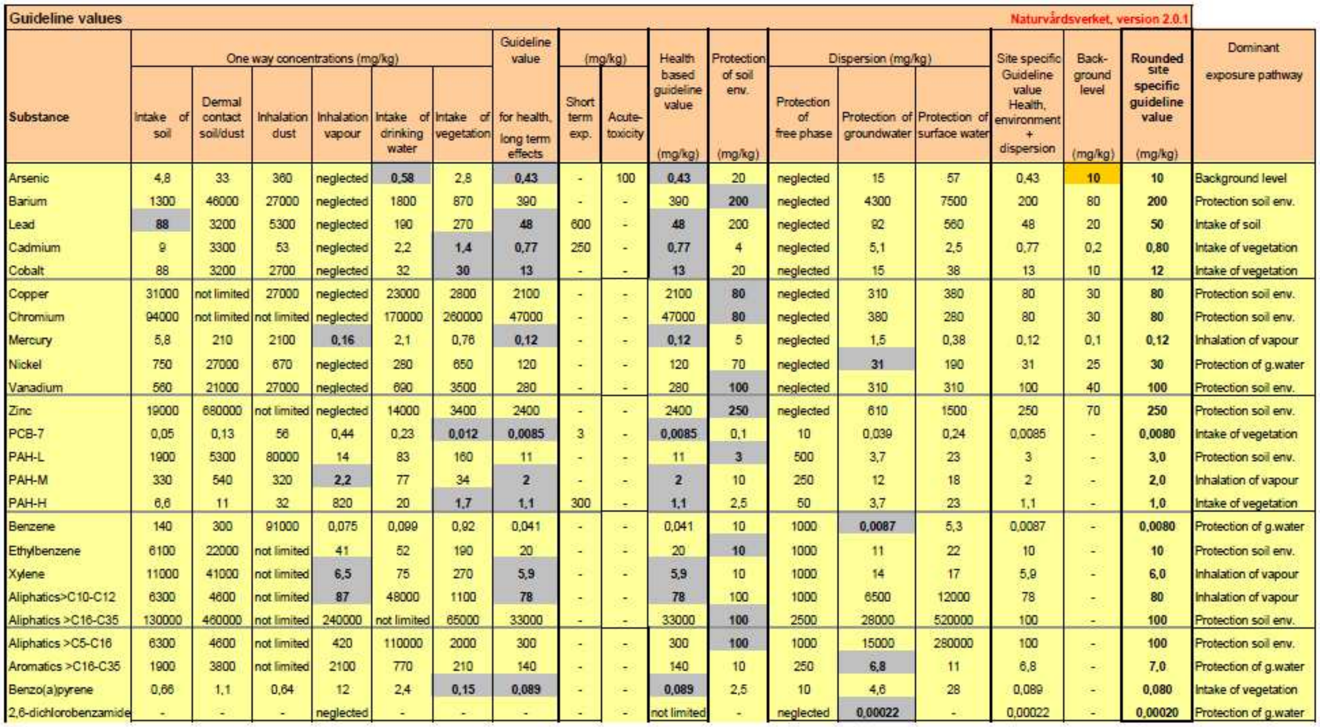
Appendix A. SITE-SPECIFIC GUIDELINES

TABLE A.1 SITE-SPECIFIC GUIDELINES

Gray cells indicate that this value is controlling for the guideline value. Orange cell indicates that the guideline has been adjusted to the background level.



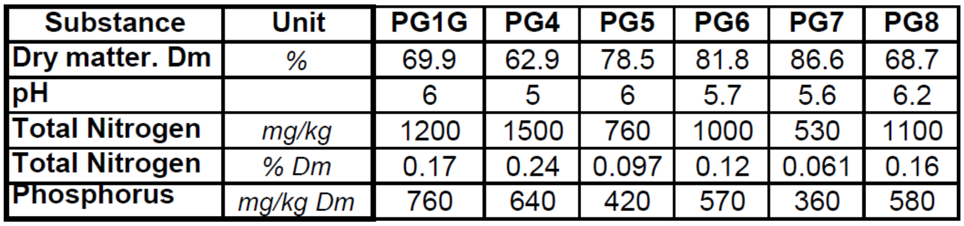
Guideline values

Naturvårdsverket, version 2.0.1

	One way concentrations (mg/kg)						Guideline value	(mg/kg)		Health based guideline value	Protection of soil env.	Dispersion (mg/kg)			Site specific Guideline value Health, environment + dispersion	Back-ground level	Rounded site specific guideline value	Dominant exposure pathway
Substance	Intake of soil	Dermal contact soil/dust	Inhalation dust	Inhalation vapour	Intake of drinking water	Intake of vegetation	for health, long term effects	Short term exp.	Acute-toxicity	(mg/kg)	(mg/kg)	Protection of free phase	Protection of groundwater	Protection of surface water		(mg/kg)	(mg/kg)	
Arsenic	4,8	33	360	neglected	**0,58**	2,8	**0,43**	-	100	**0,43**	20	neglected	15	57	0,43	**10**	**10**	Background level
Barium	1300	46000	27000	neglected	1800	870	390	-	-	390	**200**	neglected	4300	7500	200	80	**200**	Protection soil env.
Lead	**88**	3200	5300	neglected	190	270	**48**	600	-	**48**	200	neglected	92	560	48	20	**50**	Intake of soil
Cadmium	9	3300	53	neglected	2,2	**1,4**	**0,77**	250	-	**0,77**	4	neglected	5,1	2,5	0,77	0,2	**0,80**	Intake of vegetation
Cobalt	88	3200	2700	neglected	32	**30**	**13**	-	-	**13**	20	neglected	15	38	13	10	**12**	Intake of vegetation
Copper	31000	not limited	27000	neglected	23000	2800	2100	-	-	2100	**80**	neglected	310	380	80	30	**80**	Protection soil env.
Chromium	94000	not limited	not limited	neglected	170000	260000	47000	-	-	47000	**80**	neglected	380	280	80	30	**80**	Protection soil env.
Mercury	5,8	210	2100	**0,16**	2,1	0,76	**0,12**	-	-	**0,12**	5	neglected	1,5	0,38	0,12	0,1	**0,12**	Inhalation of vapour
Nickel	750	27000	670	neglected	280	650	120	-	-	120	70	neglected	**31**	190	31	25	**30**	Protection of g.water
Vanadium	560	21000	27000	neglected	690	3500	280	-	-	280	**100**	neglected	310	310	100	40	**100**	Protection soil env.
Zinc	19000	680000	not limited	neglected	14000	3400	2400	-	-	2400	**250**	neglected	610	1500	250	70	**250**	Protection soil env.
PCB-7	0,05	0,13	56	0,44	0,23	**0,012**	**0,0085**	3	-	**0,0085**	0,1	10	0,039	0,24	0,0085	-	**0,0080**	Intake of vegetation
PAH-L	1900	5300	80000	14	83	160	11	-	-	11	**3**	500	3,7	23	3	-	**3,0**	Protection soil env.
PAH-M	330	540	320	**2,2**	77	34	**2**	-	-	**2**	10	250	12	18	2	-	**2,0**	Inhalation of vapour
PAH-H	6,6	11	32	820	20	**1,7**	**1,1**	300	-	**1,1**	2,5	50	3,7	23	1,1	-	**1,0**	Intake of vegetation
Benzene	140	300	91000	0,075	0,099	0,92	0,041	-	-	0,041	10	1000	**0,0087**	5,3	0,0087	-	**0,0080**	Protection of g.water
Ethylbenzene	6100	22000	not limited	41	52	190	20	-	-	20	**10**	1000	11	22	10	-	**10**	Protection soil env.
Xylene	11000	41000	not limited	**6,5**	75	270	**5,9**	-	-	**5,9**	10	1000	14	17	5,9	-	**6,0**	Inhalation of vapour
Aliphatics>C10-C12	6300	4600	not limited	**87**	48000	1100	**78**	-	-	**78**	100	1000	6500	12000	78	-	**80**	Inhalation of vapour
Aliphatics >C16-C35	130000	460000	not limited	240000	not limited	65000	33000	-	-	33000	**100**	2500	28000	520000	100	-	**100**	Protection soil env.
Aliphatics >C5-C16	6300	4600	not limited	420	110000	2000	300	-	-	300	**100**	1000	15000	280000	100	-	**100**	Protection soil env.
Aromatics >C16-C35	1900	3800	not limited	2100	770	210	140	-	-	140	10	250	**6,8**	11	6,8	-	**7,0**	Protection of g.water
Benzo(a)pyrene	0,66	1,1	0,64	12	2,4	**0,15**	**0,089**	-	-	**0,089**	2,5	10	4,6	28	0,089	-	**0,080**	Intake of vegetation
2,6-dichlorobenzamide	-	-	-	neglected	-	-	-	-	-	not limited	-	neglected	**0,00022**	-	0,00022	-	**0,00020**	Protection of g.water

APPENDIX B. SOIL SAMPLE RESULTS

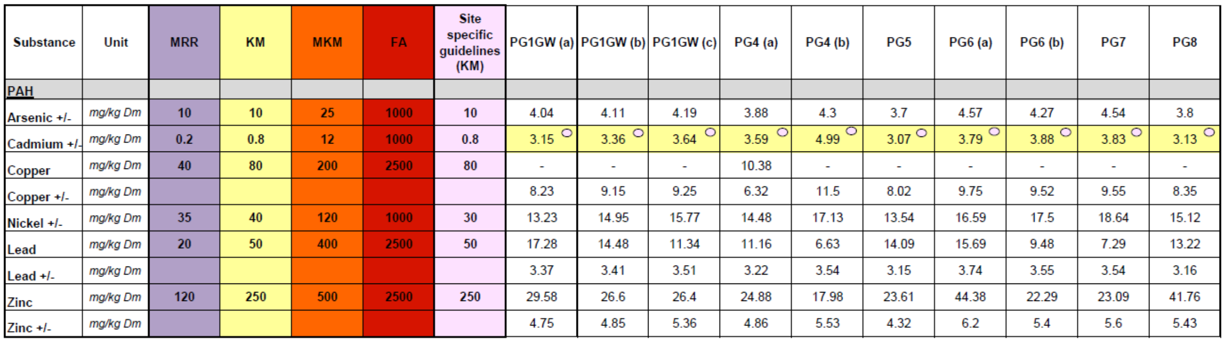
TABLE B.1 GENERAL PARAMETERS OF SOIL SAMPLES



Substance	Unit	PG1G	PG4	PG5	PG6	PG7	PG8
Dry matter. Dm	%	69.9	62.9	78.5	81.8	86.6	68.7
pH		6	5	6	5.7	5.6	6.2
Total Nitrogen	*mg/kg*	1200	1500	760	1000	530	1100
Total Nitrogen	*% Dm*	0.17	0.24	0.097	0.12	0.061	0.16
Phosphorus	*mg/kg Dm*	760	640	420	570	360	580

TABLE B.2 XRF-RESULTS

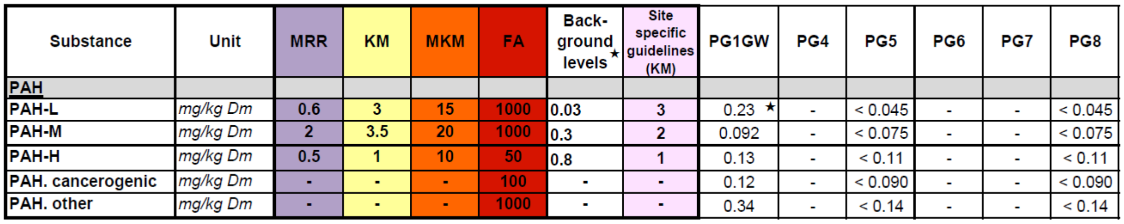
Result of the XRF screening assessment where the metal content in soil was investigated. Some samples were run multiple times for validation. These are marked (a) (b) and (c). Guidelines regarding MRR is derived from Swedish EPA handbook 2010:1 (Naturvårdsverket 2010), KM and MKM from the Swedish EPA 2009 (Naturvårdsverket 2009a) and FA guideline is from the Swedish Waste Management Association (Avfall Sverige 2019). The site-specific guideline for KM was derived from the Swedish EPA model (Naturvårdsverket 2019b)



Substance	Unit	MRR	KM	MKM	FA	Site specific guidelines (KM)	PG1GW (a)	PG1GW (b)	PG1GW (c)	PG4 (a)	PG4 (b)	PG5	PG6 (a)	PG6 (b)	PG7	PG8
PAH																
Arsenic +/-	*mg/kg Dm*	10	10	25	1000	10	4.04	4.11	4.19	3.88	4.3	3.7	4.57	4.27	4.54	3.8
Cadmium +/-	*mg/kg Dm*	0.2	0.8	12	1000	0.8	3.15 ○	3.36 ○	3.64 ○	3.59 ○	4.99 ○	3.07 ○	3.79 ○	3.88 ○	3.83 ○	3.13 ○
Copper	*mg/kg Dm*	40	80	200	2500	80	-	-	-	10.38	-	-	-	-	-	-
Copper +/-	*mg/kg Dm*						8.23	9.15	9.25	6.32	11.5	8.02	9.75	9.52	9.55	8.35
Nickel +/-	*mg/kg Dm*	35	40	120	1000	30	13.23	14.95	15.77	14.48	17.13	13.54	16.59	17.5	18.64	15.12
Lead	*mg/kg Dm*	20	50	400	2500	50	17.28	14.48	11.34	11.16	6.63	14.09	15.69	9.48	7.29	13.22
Lead +/-	*mg/kg Dm*						3.37	3.41	3.51	3.22	3.54	3.15	3.74	3.55	3.54	3.16
Zinc	*mg/kg Dm*	120	250	500	2500	250	29.58	26.6	26.4	24.88	17.98	23.61	44.38	22.29	23.09	41.76
Zinc +/-	*mg/kg Dm*						4.75	4.85	5.36	4.86	5.53	4.32	6.2	5.4	5.6	5.43

TABLE B.3 PAH CONTENT IN SOIL

Guidelines regarding MRR from Swedish EPA handbook 2010:1 (Naturvårdsverket 2010), KM and MKM from Swedish EPA 2009 (Naturvårdsverket 2009a) and FA guideline from Swedish Waste Management Association (Avfall Sverige 2019). Background levels from Kemakta (2015), where the level of the 90th percentile was selected for background levels in rural areas.



Substance	Unit	MRR	KM	MKM	FA	Back-ground levels ★	Site specific guidelines (KM)	PG1GW	PG4	PG5	PG6	PG7	PG8
PAH													
PAH-L	*mg/kg Dm*	0.6	3	15	1000	0.03	3	0.23 ★	-	< 0.045	-	-	< 0.045
PAH-M	*mg/kg Dm*	2	3.5	20	1000	0.3	2	0.092	-	< 0.075	-	-	< 0.075
PAH-H	*mg/kg Dm*	0.5	1	10	50	0.8	1	0.13	-	< 0.11	-	-	< 0.11
PAH. cancerogenic	*mg/kg Dm*	-	-	-	100	-	-	0.12	-	< 0.090	-	-	< 0.090
PAH. other	*mg/kg Dm*	-	-	-	1000	-	-	0.34	-	< 0.14	-	-	< 0.14

TABLE B.4 PETROLEUMS CONTENT IN SOIL

Guidelines regarding KM and MKM from Swedish EPA 2009 (Naturvårdsverket 2009a) and FA guideline from Swedish Waste Management Association (Avfall Sverige 2019). Values exceeding the detection limit (regarded as the background lavel) is marked with a star. Site Specific guidelines from the Swedish EPA model (Naturvårdsverket 2019b).

Substance	Unit	MRR	KM	MKM	FA	Site specific guidelines (KM)	PG1GW	PG4	PG5	PG6	PG7	PG8
Petroleums												
Benzene	*mg/kg Dm*	**-**	**0.012**	**0.04**	**1000**	**0.008**	< 0.0035	-	-	-	-	< 0.0035
Ethylbenzene	*mg/kg Dm*	**-**	**10**	**50**	**1000**	**10**	< 0.10	-	-	-	-	< 0.10
M/P/O-Xylene	*mg/kg Dm*	**-**	**10**	**50**	**1000**	**6**	< 0.10	-	-	-	-	< 0.10
Toluene	*mg/kg Dm*	**-**	**10**	**40**	**1000**	**-**	< 0.10	-	-	-	-	< 0.10
Aliphatics >C5-C8	*mg/kg Dm*	**-**	**25**	**150**	**700**	**-**	< 5.0	-	-	-	-	< 5.0
Aliphatics>C8-C10	*mg/kg Dm*	**-**	**25**	**120**	**700**	**-**	< 3.0	-	-	-	-	< 3.0
Aliphatics>C10-C12	*mg/kg Dm*	**-**	**100**	**500**	**1000**	**80**	6 ★	-	-	-	-	< 5.0
Aliphatics >C12-C16	*mg/kg Dm*	**-**	**100**	**500**	**10000**	**-**	< 5.0 ★	-	-	-	-	< 5.0
Aliphatics >C5-C16	*mg/kg Dm*	**-**	**100**	**500**	**-**	**100**	13	-	-	-	-	< 9.0
Aliphatics >C16-C35	*mg/kg Dm*	**-**	**100**	**1000**	**10000**	**100**	34 ★	-	-	-	-	< 10
Aromatics >C8-C10	*mg/kg Dm*	**-**	**10**	**50**	**1000**	**-**	< 4.0	-	-	-	-	< 4.0
Aromatics >C10-C16	*mg/kg Dm*	**-**	**3**	**15**	**1000**	**-**	< 0.90	-	-	-	-	< 0.90
Aromatics >C16-C35	*mg/kg Dm*	**-**	**10**	**30**	**1000**	**7**	0.77 ★	-	-	-	-	< 0.50

APPENDIX C. GROUNDWATER SAMPLE RESULTS

TABLE C.1 GENERAL PARAMETERS OF GROUNDWATER SAMPLES

Substance	Unit	PG1GW	PG2GW	PG3GW	PG5	PG8
pH		6.2	6.3	6.9	5.9	6.2
Phosphorus	*mg/l*	0.53	0.47	0.65	12	61
Nitrogen	*mg/l*	4.7	4.3	4	53	110

APPENDIX D. MODFLOW

TABLE D.1 COORDINATES AND GROUNDWATER PARAMETERS

Sample	Unit	x	y	z	Ground surface (over Emån)	Depth to gw	Gw table	Hydraulic head (Gw table over Emån)	Hydraulic head in GMS (Gw table over Emån if Emån= 1m)
					z- 151	*Measured in field*	*z-Depth to gw*	*Gw table- 151*	*Hydraulic head + 1m*
PG1GW	*m*	6370423.8	250863	156.24	5.244	3.81	152.43	1.434	2.434
PG2GW	*m*	6370478.4	250940	154.24	3.236	2.78	151.46	0.456	1.456
PG3GW	*m*	6370423.3	250967	153.81	2.808	2.18	151.63	0.628	1.628
PG5	*m*	6370365.4	250932	154.41	3.411	2	152.41	1.411	2.411
PG8	*m*	6370437	250880	156.31	5.31	4	152.31	1.31	2.31

TABLE D.2 PARAMETERS IN GMS

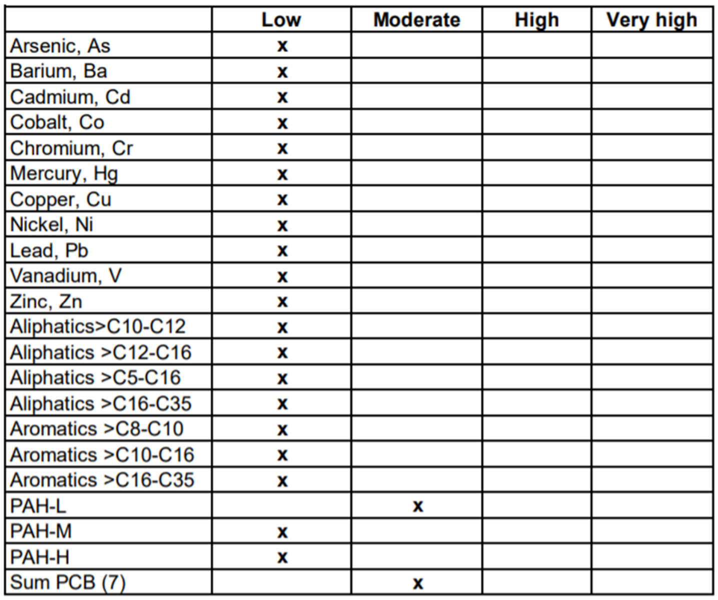
Parameter	Unit	Value
Length of grid in X dimension	*m*	162.72
Length of grid in Y dimension	*m*	126.64
Length of grid in Z dimension	*m*	8
No. of blocks X	-	20
No. of blocks Y	-	15
No. of blocks Z	-	2
Area of blocks (on the surface)	m^2	69
Number of active blocks (surface)	-	231
Area of model (surface)	m^2	15939
Horizontal k layer 1	*m/d*	4.32
Horizontal k layer 2	*m/d*	0.0432
Fraction organic carbon foc	*kg/kg*	0.02
Porosity ε	m^3/m^3	0.4
Precipitation (P)	*m/d*	0.001792
Evaporation (E)	*m/d*	0.00109589
Recharge: Rainfall infiltration (P-E)	*m/d*	0.00069611
Recharge upper row	*m/d*	0.003-0.03
Bulk density	kg/m^3	778

TABLE D.3 k_d – VALUES USED

	k_{oc} *l/kg*	f_{oc} -	k_d *l/kg*	k_d m^3/kg
Arsenic, As			80	**0.08**
Chromium, Cr			15	**0.015**
Nickel, Ni			300	**0.3**
Lead, Pb			1800	**1.8**
Zinc, Zn			600	**0.6**
Benzo(a)pyren	661000	0.02	13220	**13.22**
Benso(k)fluoranten	174000	0.02	3480	**3.48**
Benso(b)fluoranten	219000	0.02	4380	**4.38**
Benzo(g,h,i)perylen	3E+06	0.02	53800	**53.8**
Indeno(1,2,3-cd)pyren	1E+06	0.02	21000	**21**
2,6-dichlorobenzamide			0.42	**0.00042**

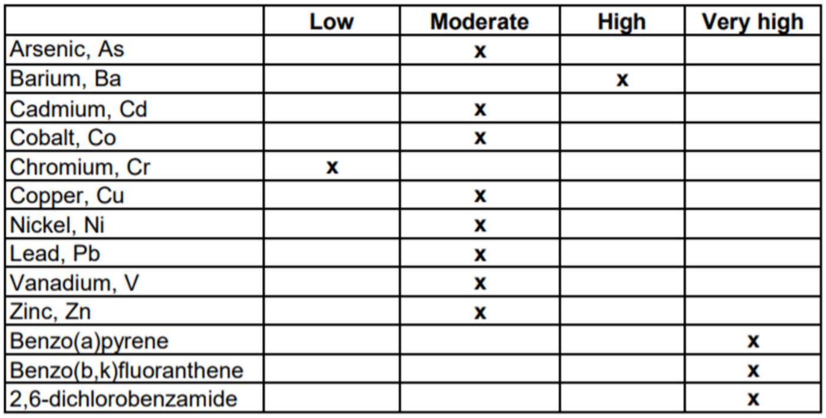
APPENDIX E. RISK ASSESSMENT

TABLE E.1 RISK RELATED TO CONTAMINATION LEVELS IN SOIL



	Low	Moderate	High	Very high
Arsenic, As	x			
Barium, Ba	x			
Cadmium, Cd	x			
Cobalt, Co	x			
Chromium, Cr	x			
Mercury, Hg	x			
Copper, Cu	x			
Nickel, Ni	x			
Lead, Pb	x			
Vanadium, V	x			
Zinc, Zn	x			
Aliphatics>C10-C12	x			
Aliphatics >C12-C16	x			
Aliphatics >C5-C16	x			
Aliphatics >C16-C35	x			
Aromatics >C8-C10	x			
Aromatics >C10-C16	x			
Aromatics >C16-C35	x			
PAH-L		x		
PAH-M	x			
PAH-H	x			
Sum PCB (7)		x		

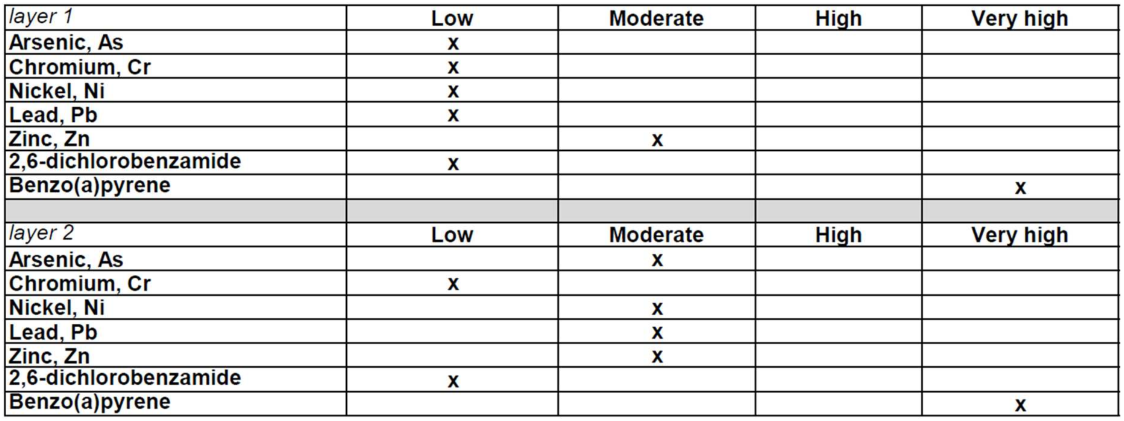
TABLE E.2 RISK RELATED TO CONTAMINATION LEVELS IN GROUNDWATER



	Low	Moderate	High	Very high
Arsenic, As		x		
Barium, Ba			x	
Cadmium, Cd		x		
Cobalt, Co		x		
Chromium, Cr	x			
Copper, Cu		x		
Nickel, Ni		x		
Lead, Pb		x		
Vanadium, V		x		
Zinc, Zn		x		
Benzo(a)pyrene				x
Benzo(b,k)fluoranthene				x
2,6-dichlorobenzamide				x

TABLE E.3 RISK RELATED TO A 50-YEARS-FROM-NOW SCENARIO

Risk classification for contamination levels in groundwater in a 50-years-from-now scenario



layer 1	Low	Moderate	High	Very high
Arsenic, As	x			
Chromium, Cr	x			
Nickel, Ni	x			
Lead, Pb	x			
Zinc, Zn		x		
2,6-dichlorobenzamide	x			
Benzo(a)pyrene				x
layer 2	**Low**	**Moderate**	**High**	**Very high**
Arsenic, As		x		
Chromium, Cr	x			
Nickel, Ni		x		
Lead, Pb		x		
Zinc, Zn		x		
2,6-dichlorobenzamide	x			
Benzo(a)pyrene				x

APPENDIX F. PROTOCOL FROM SITE INVESTIGATION

Trial pit 1 (PG1GW)

Completed: Soil samples at 4 m depth in 3 glass jars, 2 plastic jars. Groundwater monitoring well installed

Groundwater table measured in the pit: 4.3 m below the surface

PID: 7.6 ppm (taken on household waste 4 m depth).

Comment: A lot of rocks and blocks, especially in the upper 4 m (natural rocks?). Household waste was found at a 4 m depth. Dark layers visible in profile. Odour: sulfur. Oil was visible on the water surface at the bottom of the pit as well as on the water coming from the household waste which was picked up and put next to the pit. General idea of the material: Looks like organic material mixed with industrial waste. Plastic, bricks, tiles, carpets and paint cans visible. The groundwater monitoring well was installed and put at the deepest part of the pit. Around the screening part of the well, gravel/filter material was filled with material from a gravel pile adjacent to the pit.

Trial pit 2 (PG2GW)

Completed: Groundwater monitoring well installed

Depth to natural ground: 2.9 m below ground level

Groundwater table measured in the pit: 3.6 m below the surface

PID: 0

Comment: Looks like clean masses with a muddy smell. Has a lot of ungraded crushed rocks as well as old asphalt material. The asphalt has an odour of tar which may indicate that the asphalt was created before the new rules regarding asphalt came into force. One larger asphalt piece visible on the left-hand side a bit below the surface according to Figure PG2GWasfaltsbild. Infiltrating water enters the pit from the wall closest to the center of the landfill, as well as a little infiltration from the opposite wall, closest to river Emån.

Trial pit 3 (PG3GW)
Completed: Groundwater monitoring well installed
Groundwater table measured in the pit: 3.3 m below the surface
PID: 0
Comments: Looks like clean masses. Not much rubbish. The first meter looks like organic material. Dark, heterogeneous-grained soil. Moraine? Not very silty (since it holds together). Some ungraded crushed rocks mixed with natural stones. Water infiltrate the pit from the landfill side of the pit and to the right of the landfill side (if directed towards Emån).

Trial pit 4 (PG4)

Completed: Soil sample in a plastic bag

Groundwater table measured in the pit: Did not reach

PID: 0

Comments: The test pit was located on a bit east on the third step of the landfill. No household waste was found, nor the groundwater. Because of the large amount of vegetation, it was suspected that the masses origins from treatment plants and contain a lot of nutrients. The soil was dark and easy to excavate since it was very little stone the first meters. The profile showed different layers, see Figure below. The ungraded crushed rocks found was mainly towards the eastern wall (towards the river emån and pit PG3GW). Obour: sulfur. Water flows from the landfill wall towards the river Emån.

Trial pit 5 (PG5)

Completed: Soil sample in a plastic bag and groundwater/leachate from the bottom of the pit in a plastic jar.

Groundwater table measured in the pit: 2 m below the surface

PID: 0

Comments: Light brown / reddish material. A lot of ungraded crushed rocks and therefore very difficult to excavate from 1 m depth and down. No household waste found.

Trial pit 6 (PG6)

Completed: Soil sample in plastic bag

Groundwater table measured in the pit: Did not reach

PID: 0

Comment: Almost exclusively ungraded crushed rocks! Also waste in forms of tires and ropes as well as cables. A large block with cables drilled into it. Can this be remains of mine blasting and drilling? The soil looked clean, no odour and contained a lot of worms.

Trial pit 7 (PG7)

Completed: Soil sample in a plastic bag

Groundwater table measured in the pit: Did not reach

PID: 0

Comment: As the location had a well grown vegetation, the expectation was to find household waste. No household waste was found however. The soil looked like clay moraine, and the pit did not contain and ungraded crushed rocks. On the right wall (as shown) there was a section with a lot of stone. On the short side of the wall closest to the bushes, the profile was layered, and at its left corner, a section of dark masses. Here a soil sample was taken.

Trial pit 8 (PG8)
Completed: Soil sample in a plastic bag and groundwater/leachate sample in a plastic jar
Groundwater table measured in the pit: 4 m below the surface
PID: 0.1
Comment: Since the pit was located close to PG1GW (approx. 20 m) with household waste, the assumption was to find household waste at the same depth. There was no household waste found however, only asphalt pieces and ungraded crushed rocks and some brick. Visible layer sequences in the soil profile.

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Kundnummer: SL8419231

Uppdragsmärkn.
Rösaberga

Analysrapport

Provnummer:	**177-2020-03270647**	Provtagningsdatum	2020-03-25
Provbeskrivning:		Provtagare	HK
Matris:	Jord		
Provet ankom:	2020-03-26		
Utskriftsdatum:	2020-04-09		
Analyserna påbörjades:	2020-03-26		
Provmärkning:	PG1GW (SLB58-2)		
Provtagningsplats:	Rösaberga		

Analys	Resultat	Enhet	Mäto.	Metod/ref	
Torrsubstans	**69.9**	%	10%	SS-EN 12880:2000	b)
Glödförlust	**7.2**	% Ts	10%	SS-EN 12879:2000	b)
TOC beräknat	**4.1**	% Ts			b)
pH	**6.0**		0.2	SS-EN 15933:2012	b)
Bensen	**< 0.0035**	mg/kg Ts	30%	EPA 5021	b)
Toluen	**< 0.10**	mg/kg Ts	30%	EPA 5021	b)
Etylbensen	**< 0.10**	mg/kg Ts	30%	EPA 5021	b)
M/P/O-Xylen	**< 0.10**	mg/kg Ts	30%	EPA 5021	b)
Summa TEX	**< 0.20**	mg/kg Ts	30%	EPA 5021	b)
Alifater >C5-C8	**< 5.0**	mg/kg Ts	35%	SPI 2011	b)
Alifater >C8-C10	**< 3.0**	mg/kg Ts	35%	SPI 2011	b)
Alifater >C10-C12	**6.0**	mg/kg Ts	30%	SPI 2011	b)
Alifater >C12-C16	**< 5.0**	mg/kg Ts	30%	SPI 2011	b)
Summa Alifater >C5-C16	**13**	mg/kg Ts			b)
Alifater >C16-C35	**34**	mg/kg Ts	30%	SPI 2011	b)
Aromater >C8-C10	**< 4.0**	mg/kg Ts	30%	SPI 2011	b)
Aromater >C10-C16	**< 0.90**	mg/kg Ts	20%	SPI 2011	b)
Metylkrysener/benzo(a)antracener	**< 0.50**	mg/kg Ts	25%	SIS: TK 535 N 012	b)
Metylpyren/fluorantener	**0.52**	mg/kg Ts	25%	SIS: TK 535 N 012	b)
Aromater >C16-C35	**0.77**	mg/kg Ts	25%	SIS: TK 535 N 012	b)
Oljetyp < C10	**Utgår**				b)*
Oljetyp > C10	**ospec**				b)*
Bens(a)antracen	**< 0.030**	mg/kg Ts	25%	ISO 18287:2008 mod	b)
Krysen	**< 0.030**	mg/kg Ts	25%	ISO 18287:2008 mod	b)
Benso(b,k)fluoranten	**0.042**	mg/kg Ts	25%	ISO 18287:2008 mod	b)
Benzo(a)pyren	**< 0.030**	mg/kg Ts	25%	ISO 18287:2008 mod	b)

Förklaringar

Laboratoriet/laboratorierna är ackrediterade av respektive lands ackrediteringsorgan. Ej ackrediterade analyser är markerade med *

Mätosäkerheten, om inget annat anges, redovisas som utvidgad mätosäkerhet med täckningsfaktor 2. Undantag relaterat till analyser utförda utanför Sverige kan förekomma. Ytterligare upplysningar samt mätosäkerhet och detektionsnivåer för mikrobiologiska analyser lämnas på begäran.

Denna rapport får endast återges i sin helhet, om inte utförande laboratorium i förväg skriftligen godkänt annat. Resultaten relaterar endast till det insända provet.

Indeno(1,2,3-cd)pyren	**< 0.030**	mg/kg Ts	25%	ISO 18287:2008 mod	b)
Dibens(a,h)antracen	**< 0.030**	mg/kg Ts	30%	ISO 18287:2008 mod	b)
Naftalen	**0.20**	mg/kg Ts	25%	ISO 18287:2008 mod	b)
Acenaftylen	**< 0.030**	mg/kg Ts	40%	ISO 18287:2008 mod	b)
Acenaften	**< 0.030**	mg/kg Ts	25%	ISO 18287:2008 mod	b)
Fluoren	**< 0.030**	mg/kg Ts	30%	ISO 18287:2008 mod	b)
Fenantren	**< 0.030**	mg/kg Ts	25%	ISO 18287:2008 mod	b)
Antracen	**< 0.030**	mg/kg Ts	25%	ISO 18287:2008 mod	b)
Fluoranten	**0.032**	mg/kg Ts	25%	ISO 18287:2008 mod	b)
Pyren	**< 0.030**	mg/kg Ts	25%	ISO 18287:2008 mod	b)
Benzo(g,h,i)perylen	**< 0.030**	mg/kg Ts	25%	ISO 18287:2008 mod	b)
Summa PAH med låg molekylvikt	**0.23**	mg/kg Ts			b)
Summa PAH med medelhög molekylvikt	**0.092**	mg/kg Ts			b)
Summa PAH med hög molekylvikt	**0.13**	mg/kg Ts			b)
Summa cancerogena PAH	**0.12**	mg/kg Ts			b)
Summa övriga PAH	**0.34**	mg/kg Ts			b)
Summa totala PAH16	**0.45**	mg/kg Ts			b)
PCB 28	**< 0.0020**	mg/kg Ts	30%	EN 16167:2012 mod	b)
PCB 52	**< 0.0020**	mg/kg Ts	25%	EN 16167:2012 mod	b)
PCB 101	**< 0.0020**	mg/kg Ts	25%	EN 16167:2012 mod	b)
PCB 118	**< 0.0020**	mg/kg Ts	25%	EN 16167:2012 mod	b)
PCB 153	**0.0037**	mg/kg Ts	25%	EN 16167:2012 mod	b)
PCB 138	**0.0039**	mg/kg Ts	25%	EN 16167:2012 mod	b)
PCB 180	**0.0026**	mg/kg Ts	25%	EN 16167:2012 mod	b)
S:a PCB (7st)	**0.014**	mg/kg Ts		EN 16167:2012 mod	b)
Totalkväve (Kjeldahl+dewardas)	**1200**	mg/kg	10%	SS 028101	a)
Totalkväve (Kjeldahl+dewardas)	**0.17**	% Ts	20%	Beräknad från analyserad halt	b)
Arsenik As	**2.9**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Barium Ba	**73**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Bly Pb	**16**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Fosfor P	**760**	mg/kg Ts	20%	SS028311 / ICP-AES	b)
Kadmium Cd	**< 0.20**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Kobolt Co	**3.8**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Koppar Cu	**9.4**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Krom Cr	**8.6**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Kvicksilver Hg	**0.044**	mg/kg Ts	20%	SS028311mod/SS-EN ISO17852mod	b)
Nickel Ni	**10**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Vanadin V	**18**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Zink Zn	**120**	mg/kg Ts	25%	EN ISO 11885:2009 / SS	b)

				028311 utg 1	
Diklormetan	**< 0.0050**	mg/kg Ts	30%	EPA 5021	b)
Triklormetan	**< 0.0050**	mg/kg Ts	25%	EPA 5021	b)
Tetraklormetan	**< 0.0050**	mg/kg Ts	25%	EPA 5021	b)
1,1,2-Trikloreten	**< 0.0050**	mg/kg Ts	20%	EPA 5021	b)
Tetrakloreten	**< 0.0050**	mg/kg Ts	20%	EPA 5021	b)
1,1-Dikloretan	**< 0.0050**	mg/kg Ts	30%	EPA 5021	b)
1,2-Dikloretan	**< 0.0050**	mg/kg Ts	25%	EPA 5021	b)
1,1,1-Trikloretan	**< 0.0050**	mg/kg Ts	25%	EPA 5021	b)
1,1,2-Trikloretan	**< 0.0050**	mg/kg Ts	30%	EPA 5021	b)
cis-1,2-Dikloreten	**< 0.0050**	mg/kg Ts	30%	EPA 5021	b)
trans-1,2-Dikloreten	**< 0.0050**	mg/kg Ts	30%	EPA 5021	b)
Vinylklorid	**< 0.0050**	mg/kg Ts	25%	EPA 5021	b)

<u>Utförande laboratorium/underleverantör:</u>

a) Eurofins Food & Feed Testing Sweden (Lidköping), SWEDEN, ISO/IEC 17025:2005 SWEDAC 1977
b) Eurofins Environment Testing Sweden AB, SWEDEN, ISO/IEC 17025:2005 SWEDAC 1125

Gustav Stenhammar, Rapportansvarig

Denna rapport är elektroniskt signerad.

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Mätosäkerheten, om inget annat anges, redovisas som utvidgad mätosäkerhet med täckningsfaktor 2. Undantag relaterat till analyser utförda utanför Sverige kan förekomma. Ytterligare upplysningar samt mätosäkerhet och detektionsnivåer för mikrobiologiska analyser lämnas på begäran.

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Kundnummer: SL8419231

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Rösaberga

Analysrapport

Provnummer:	**177-2020-03270648**	Provtagningsdatum	2020-03-25
Provbeskrivning:		Provtagare	HK
Matris:	Jord		
Provet ankom:	2020-03-26		
Utskriftsdatum:	2020-04-09		
Analyserna påbörjades:	2020-03-26		
Provmärkning:	PG4		
Provtagningsplats:	Rösaberga		

Analys	Resultat	Enhet	Mäto.	Metod/ref	
Torrsubstans	**62.9**	%	10%	SS-EN 12880:2000	b)
Glödförlust	**< 0.1**	% Ts	10%	SS-EN 12879:2000	b)
TOC beräknat	**<0.057**	% Ts			b)
pH	**5.0**		0.2	SS-EN 15933:2012	b)
PCB 28	**< 0.0020**	mg/kg Ts	30%	EN 16167:2012 mod	b)
PCB 52	**< 0.0020**	mg/kg Ts	25%	EN 16167:2012 mod	b)
PCB 101	**< 0.0020**	mg/kg Ts	25%	EN 16167:2012 mod	b)
PCB 118	**< 0.0020**	mg/kg Ts	25%	EN 16167:2012 mod	b)
PCB 153	**< 0.0020**	mg/kg Ts	25%	EN 16167:2012 mod	b)
PCB 138	**< 0.0020**	mg/kg Ts	25%	EN 16167:2012 mod	b)
PCB 180	**< 0.0020**	mg/kg Ts	25%	EN 16167:2012 mod	b)
S:a PCB (7st)	**< 0.0070**	mg/kg Ts		EN 16167:2012 mod	b)
Totalkväve (Kjeldahl+dewardas)	**1500**	mg/kg	10%	SS 028101	a)
Totalkväve (Kjeldahl+dewardas)	**0.24**	% Ts	20%	Beräknad från analyserad halt	b)
Arsenik As	**3.6**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Barium Ba	**45**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Bly Pb	**10**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Fosfor P	**640**	mg/kg Ts	20%	SS028311 / ICP-AES	b)
Kadmium Cd	**< 0.20**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Kobolt Co	**5.3**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Koppar Cu	**25**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Krom Cr	**10**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)

Förklaringar

Laboratoriet/laboratorierna är ackrediterade av respektive lands ackrediteringsorgan. Ej ackrediterade analyser är markerade med *

Mätosäkerheten, om inget annat anges, redovisas som utvidgad mätosäkerhet med täckningsfaktor 2. Undantag relaterat till analyser utförda utanför Sverige kan förekomma. Ytterligare upplysningar samt mätosäkerhet och detektionsnivåer för mikrobiologiska analyser lämnas på begäran.

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Kvicksilver Hg	**0.025**	mg/kg Ts	20%	SS028311mod/SS-EN ISO17852mod	b)
Nickel Ni	**6.8**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Vanadin V	**21**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Zink Zn	**110**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)

Utförande laboratorium/underleverantör:

a) Eurofins Food & Feed Testing Sweden (Lidköping), SWEDEN, ISO/IEC 17025:2005 SWEDAC 1977
b) Eurofins Environment Testing Sweden AB, SWEDEN, ISO/IEC 17025:2005 SWEDAC 1125

Gustav Stenhammar, Rapportansvarig

Denna rapport är elektroniskt signerad.

Förklaringar

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Mätosäkerheten, om inget annat anges, redovisas som utvidgad mätosäkerhet med täckningsfaktor 2. Undantag relaterat till analyser utförda utanför Sverige kan förekomma. Ytterligare upplysningar samt mätosäkerhet och detektionsnivåer för mikrobiologiska analyser lämnas på begäran.

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AR-20-SL-080205-01

EUSELI2-00741021
Kundnummer: SL8419231

Uppdragsmärkn.
Rösaberga

Analysrapport

Provnummer:	**177-2020-03270649**	Provtagningsdatum	2020-03-25
Provbeskrivning:		Provtagare	HK
Matris:	Jord		
Provet ankom:	2020-03-26		
Utskriftsdatum:	2020-04-09		
Analyserna påbörjades:	2020-03-26		
Provmärkning:	PG5		
Provtagningsplats:	Rösaberga		

Analys	Resultat	Enhet	Mäto.	Metod/ref	
Torrsubstans	**78.5**	%	10%	SS-EN 12880:2000	b)
Glödförlust	**3.6**	% Ts	10%	SS-EN 12879:2000	b)
TOC beräknat	**2.1**	% Ts			b)
pH	**6.0**		0.2	SS-EN 15933:2012	b)
Bens(a)antracen	**< 0.030**	mg/kg Ts	25%	ISO 18287:2008 mod	b)
Krysen	**< 0.030**	mg/kg Ts	25%	ISO 18287:2008 mod	b)
Benso(b,k)fluoranten	**< 0.030**	mg/kg Ts	25%	ISO 18287:2008 mod	b)
Benzo(a)pyren	**< 0.030**	mg/kg Ts	25%	ISO 18287:2008 mod	b)
Indeno(1,2,3-cd)pyren	**< 0.030**	mg/kg Ts	25%	ISO 18287:2008 mod	b)
Dibens(a,h)antracen	**< 0.030**	mg/kg Ts	30%	ISO 18287:2008 mod	b)
Naftalen	**< 0.030**	mg/kg Ts	25%	ISO 18287:2008 mod	b)
Acenaftylen	**< 0.030**	mg/kg Ts	40%	ISO 18287:2008 mod	b)
Acenaften	**< 0.030**	mg/kg Ts	25%	ISO 18287:2008 mod	b)
Fluoren	**< 0.030**	mg/kg Ts	30%	ISO 18287:2008 mod	b)
Fenantren	**< 0.030**	mg/kg Ts	25%	ISO 18287:2008 mod	b)
Antracen	**< 0.030**	mg/kg Ts	25%	ISO 18287:2008 mod	b)
Fluoranten	**< 0.030**	mg/kg Ts	25%	ISO 18287:2008 mod	b)
Pyren	**< 0.030**	mg/kg Ts	25%	ISO 18287:2008 mod	b)
Benzo(g,h,i)perylen	**< 0.030**	mg/kg Ts	25%	ISO 18287:2008 mod	b)
Summa PAH med låg molekylvikt	**< 0.045**	mg/kg Ts			b)
Summa PAH med medelhög molekylvikt	**< 0.075**	mg/kg Ts			b)
Summa PAH med hög molekylvikt	**< 0.11**	mg/kg Ts			b)
Summa cancerogena PAH	**< 0.090**	mg/kg Ts			b)
Summa övriga PAH	**< 0.14**	mg/kg Ts			b)
Summa totala PAH16	**< 0.23**	mg/kg Ts			b)
PCB 28	**< 0.0020**	mg/kg Ts	30%	EN 16167:2012 mod	b)

Förklaringar

Laboratoriet/laboratorierna är ackrediterade av respektive lands ackrediteringsorgan. Ej ackrediterade analyser är markerade med *

Mätosäkerheten, om inget annat anges, redovisas som utvidgad mätosäkerhet med täckningsfaktor 2. Undantag relaterat till analyser utförda utanför Sverige kan förekomma. Ytterligare upplysningar samt mätosäkerhet och detektionsnivåer för mikrobiologiska analyser lämnas på begäran.

Denna rapport får endast återges i sin helhet, om inte utförande laboratorium i förväg skriftligen godkänt annat. Resultaten relaterar endast till det insända provet.

PCB 52	**< 0.0020**	mg/kg Ts	25%	EN 16167:2012 mod	b)
PCB 101	**< 0.0020**	mg/kg Ts	25%	EN 16167:2012 mod	b)
PCB 118	**< 0.0020**	mg/kg Ts	25%	EN 16167:2012 mod	b)
PCB 153	**< 0.0020**	mg/kg Ts	25%	EN 16167:2012 mod	b)
PCB 138	**< 0.0020**	mg/kg Ts	25%	EN 16167:2012 mod	b)
PCB 180	**< 0.0020**	mg/kg Ts	25%	EN 16167:2012 mod	b)
S:a PCB (7st)	**< 0.0070**	mg/kg Ts		EN 16167:2012 mod	b)
Totalkväve (Kjeldahl+dewardas)	**760**	mg/kg	20%	SS 028101	a)
Totalkväve (Kjeldahl+dewardas)	**0.097**	% Ts	20%	Beräknad från analyserad halt	b)
Arsenik As	**< 2.3**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Barium Ba	**38**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Bly Pb	**5.9**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Fosfor P	**420**	mg/kg Ts	20%	SS028311 / ICP-AES	b)
Kadmium Cd	**< 0.20**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Kobolt Co	**5.7**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Koppar Cu	**5.5**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Krom Cr	**8.2**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Kvicksilver Hg	**0.024**	mg/kg Ts	20%	SS028311mod/SS-EN ISO17852mod	b)
Nickel Ni	**5.1**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Vanadin V	**16**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Zink Zn	**26**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)

Utförande laboratorium/underleverantör:

a) Eurofins Food & Feed Testing Sweden (Lidköping), SWEDEN, ISO/IEC 17025:2005 SWEDAC 1977
b) Eurofins Environment Testing Sweden AB, SWEDEN, ISO/IEC 17025:2005 SWEDAC 1125

Gustav Stenhammar, Rapportansvarig

Denna rapport är elektroniskt signerad.

Förklaringar

AR-003v55

Laboratoriet/laboratorierna är ackrediterade av respektive lands ackrediteringsorgan. Ej ackrediterade analyser är markerade med *

Mätosäkerheten, om inget annat anges, redovisas som utvidgad mätosäkerhet med täckningsfaktor 2. Undantag relaterat till analyser utförda utanför Sverige kan förekomma. Ytterligare upplysningar samt mätosäkerhet och detektionsnivåer för mikrobiologiska analyser lämnas på begäran.

Denna rapport får endast återges i sin helhet, om inte utförande laboratorium i förväg skriftligen godkänt annat. Resultaten relaterar endast till det insända provet.

SWEDAC ACKREDITERING
Ackred. nr 1125
Provning
ISO/IEC 17025

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AR-20-SL-080206-01

EUSELI2-00741021
Kundnummer: SL8419231

Uppdragsmärkn.
Rösaberga

Analysrapport

Provnummer:	**177-2020-03270650**	Provtagningsdatum	2020-03-25
Provbeskrivning:		Provtagare	HK
Matris:	Jord		
Provet ankom:	2020-03-26		
Utskriftsdatum:	2020-04-09		
Analyserna påbörjades:	2020-03-26		
Provmärkning:	PG6		
Provtagningsplats:	Rösaberga		

Analys	Resultat	Enhet	Mäto.	Metod/ref	
Torrsubstans	**81.8**	%	10%	SS-EN 12880:2000	b)
Glödförlust	**0.8**	% Ts	10%	SS-EN 12879:2000	b)
TOC beräknat	**0.46**	% Ts			b)
pH	**5.7**		0.2	SS-EN 15933:2012	b)
PCB 28	**< 0.0020**	mg/kg Ts	30%	EN 16167:2012 mod	b)
PCB 52	**< 0.0020**	mg/kg Ts	25%	EN 16167:2012 mod	b)
PCB 101	**< 0.0020**	mg/kg Ts	25%	EN 16167:2012 mod	b)
PCB 118	**< 0.0020**	mg/kg Ts	25%	EN 16167:2012 mod	b)
PCB 153	**< 0.0020**	mg/kg Ts	25%	EN 16167:2012 mod	b)
PCB 138	**< 0.0020**	mg/kg Ts	25%	EN 16167:2012 mod	b)
PCB 180	**< 0.0020**	mg/kg Ts	25%	EN 16167:2012 mod	b)
S:a PCB (7st)	**< 0.0070**	mg/kg Ts		EN 16167:2012 mod	b)
Totalkväve (Kjeldahl+dewardas)	**1000**	mg/kg	10%	SS 028101	a)
Totalkväve (Kjeldahl+dewardas)	**0.12**	% Ts	20%	Beräknad från analyserad halt	b)
Arsenik As	**< 2.3**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Barium Ba	**40**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Bly Pb	**6.7**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Fosfor P	**570**	mg/kg Ts	20%	SS028311 / ICP-AES	b)
Kadmium Cd	**< 0.20**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Kobolt Co	**6.4**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Koppar Cu	**13**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Krom Cr	**9.2**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)

Förklaringar

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Mätosäkerheten, om inget annat anges, redovisas som utvidgad mätosäkerhet med täckningsfaktor 2. Undantag relaterat till analyser utförda utanför Sverige kan förekomma. Ytterligare upplysningar samt mätosäkerhet och detektionsnivåer för mikrobiologiska analyser lämnas på begäran.

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Kvicksilver Hg	**0.023**	mg/kg Ts	20%	SS028311mod/SS-EN ISO17852mod	b)
Nickel Ni	**5.4**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Vanadin V	**19**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Zink Zn	**35**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)

Utförande laboratorium/underleverantör:

a) Eurofins Food & Feed Testing Sweden (Lidköping), SWEDEN, ISO/IEC 17025:2005 SWEDAC 1977
b) Eurofins Environment Testing Sweden AB, SWEDEN, ISO/IEC 17025:2005 SWEDAC 1125

Gustav Stenhammar, Rapportansvarig

Denna rapport är elektroniskt signerad.

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Mätosäkerheten, om inget annat anges, redovisas som utvidgad mätosäkerhet med täckningsfaktor 2. Undantag relaterat till analyser utförda utanför Sverige kan förekomma. Ytterligare upplysningar samt mätosäkerhet och detektionsnivåer för mikrobiologiska analyser lämnas på begäran.

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AR-20-SL-080207-01

EUSELI2-00741021
Kundnummer: SL8419231

Uppdragsmärkn.
Rösaberga

Analysrapport

Provnummer:	**177-2020-03270651**	Provtagningsdatum	2020-03-25
Provbeskrivning:		Provtagare	HK
Matris:	Jord		
Provet ankom:	2020-03-26		
Utskriftsdatum:	2020-04-09		
Analyserna påbörjades:	2020-03-26		
Provmärkning:	PG7		
Provtagningsplats:	Rösaberga		

Analys	Resultat	Enhet	Mäto.	Metod/ref	
Torrsubstans	**86.6**	%	10%	SS-EN 12880:2000	b)
Glödförlust	**2.3**	% Ts	10%	SS-EN 12879:2000	b)
TOC beräknat	**1.3**	% Ts			b)
pH	**5.6**		0.2	SS-EN 15933:2012	b)
PCB 28	**< 0.0020**	mg/kg Ts	30%	EN 16167:2012 mod	b)
PCB 52	**< 0.0020**	mg/kg Ts	25%	EN 16167:2012 mod	b)
PCB 101	**< 0.0020**	mg/kg Ts	25%	EN 16167:2012 mod	b)
PCB 118	**< 0.0020**	mg/kg Ts	25%	EN 16167:2012 mod	b)
PCB 153	**< 0.0020**	mg/kg Ts	25%	EN 16167:2012 mod	b)
PCB 138	**< 0.0020**	mg/kg Ts	25%	EN 16167:2012 mod	b)
PCB 180	**< 0.0020**	mg/kg Ts	25%	EN 16167:2012 mod	b)
S:a PCB (7st)	**< 0.0070**	mg/kg Ts		EN 16167:2012 mod	b)
Totalkväve (Kjeldahl+dewardas)	**530**	mg/kg	20%	SS 028101	a)
Totalkväve (Kjeldahl+dewardas)	**0.061**	% Ts	20%	Beräknad från analyserad halt	b)
Arsenik As	**< 2.1**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Barium Ba	**27**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Bly Pb	**3.0**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Fosfor P	**360**	mg/kg Ts	20%	SS028311 / ICP-AES	b)
Kadmium Cd	**< 0.20**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Kobolt Co	**4.8**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Koppar Cu	**5.2**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Krom Cr	**8.4**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)

Förklaringar

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Mätosäkerheten, om inget annat anges, redovisas som utvidgad mätosäkerhet med täckningsfaktor 2. Undantag relaterat till analyser utförda utanför Sverige kan förekomma. Ytterligare upplysningar samt mätosäkerhet och detektionsnivåer för mikrobiologiska analyser lämnas på begäran.
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Kvicksilver Hg	**0.020**	mg/kg Ts	20%	SS028311mod/SS-EN ISO17852mod	b)
Nickel Ni	**4.0**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Vanadin V	**19**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Zink Zn	**16**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)

Utförande laboratorium/underleverantör:

a) Eurofins Food & Feed Testing Sweden (Lidköping), SWEDEN, ISO/IEC 17025:2005 SWEDAC 1977
b) Eurofins Environment Testing Sweden AB, SWEDEN, ISO/IEC 17025:2005 SWEDAC 1125

Gustav Stenhammar, Rapportansvarig

Denna rapport är elektroniskt signerad.

Förklaringar

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Mätosäkerheten, om inget annat anges, redovisas som utvidgad mätosäkerhet med täckningsfaktor 2. Undantag relaterat till analyser utförda utanför Sverige kan förekomma. Ytterligare upplysningar samt mätosäkerhet och detektionsnivåer för mikrobiologiska analyser lämnas på begäran.

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Ackred. nr 1125
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AR-20-SL-080208-01

EUSELI2-00741021
Kundnummer: SL8419231

Uppdragsmärkn.
Rösaberga

Analysrapport

Provnummer:	**177-2020-03270652**	Provtagningsdatum	2020-03-25
Provbeskrivning:		Provtagare	HK
Matris:	Jord		
Provet ankom:	2020-03-26		
Utskriftsdatum:	2020-04-09		
Analyserna påbörjades:	2020-03-26		
Provmärkning:	PG8 (SLB58-2)		
Provtagningsplats:	Rösaberga		

Analys	Resultat	Enhet	Mäto.	Metod/ref	
Torrsubstans	**68.7**	%	10%	SS-EN 12880:2000	b)
Glödförlust	**6.4**	% Ts	10%	SS-EN 12879:2000	b)
TOC beräknat	**3.6**	% Ts			b)
pH	**6.2**		0.2	SS-EN 15933:2012	b)
Bensen	**< 0.0035**	mg/kg Ts	30%	EPA 5021	b)
Toluen	**< 0.10**	mg/kg Ts	30%	EPA 5021	b)
Etylbensen	**< 0.10**	mg/kg Ts	30%	EPA 5021	b)
M/P/O-Xylen	**< 0.10**	mg/kg Ts	30%	EPA 5021	b)
Summa TEX	**< 0.20**	mg/kg Ts	30%	EPA 5021	b)
Alifater >C5-C8	**< 5.0**	mg/kg Ts	35%	SPI 2011	b)
Alifater >C8-C10	**< 3.0**	mg/kg Ts	35%	SPI 2011	b)
Alifater >C10-C12	**< 5.0**	mg/kg Ts	30%	SPI 2011	b)
Alifater >C12-C16	**< 5.0**	mg/kg Ts	30%	SPI 2011	b)
Summa Alifater >C5-C16	**< 9.0**	mg/kg Ts			b)
Alifater >C16-C35	**< 10**	mg/kg Ts	30%	SPI 2011	b)
Aromater >C8-C10	**< 4.0**	mg/kg Ts	30%	SPI 2011	b)
Aromater >C10-C16	**< 0.90**	mg/kg Ts	20%	SPI 2011	b)
Metylkrysener/benzo(a)antracener	**< 0.50**	mg/kg Ts	25%	SIS: TK 535 N 012	b)
Metylpyren/fluorantener	**< 0.50**	mg/kg Ts	25%	SIS: TK 535 N 012	b)
Aromater >C16-C35	**< 0.50**	mg/kg Ts	25%	SIS: TK 535 N 012	b)
Oljetyp < C10	**Utgår**				b)*
Oljetyp > C10	**Utgår**				b)*
Bens(a)antracen	**< 0.030**	mg/kg Ts	25%	ISO 18287:2008 mod	b)
Krysen	**< 0.030**	mg/kg Ts	25%	ISO 18287:2008 mod	b)
Benso(b,k)fluoranten	**< 0.030**	mg/kg Ts	25%	ISO 18287:2008 mod	b)
Benzo(a)pyren	**< 0.030**	mg/kg Ts	25%	ISO 18287:2008 mod	b)

Förklaringar

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Mätosäkerheten, om inget annat anges, redovisas som utvidgad mätosäkerhet med täckningsfaktor 2. Undantag relaterat till analyser utförda utanför Sverige kan förekomma. Ytterligare upplysningar samt mätosäkerhet och detektionsnivåer för mikrobiologiska analyser lämnas på begäran.

Denna rapport får endast återges i sin helhet, om inte utförande laboratorium i förväg skriftligen godkänt annat. Resultaten relaterar endast till det insända provet.

Indeno(1,2,3-cd)pyren	**< 0.030**	mg/kg Ts	25%	ISO 18287:2008 mod	b)
Dibens(a,h)antracen	**< 0.030**	mg/kg Ts	30%	ISO 18287:2008 mod	b)
Naftalen	**< 0.030**	mg/kg Ts	25%	ISO 18287:2008 mod	b)
Acenaftylen	**< 0.030**	mg/kg Ts	40%	ISO 18287:2008 mod	b)
Acenaften	**< 0.030**	mg/kg Ts	25%	ISO 18287:2008 mod	b)
Fluoren	**< 0.030**	mg/kg Ts	30%	ISO 18287:2008 mod	b)
Fenantren	**< 0.030**	mg/kg Ts	25%	ISO 18287:2008 mod	b)
Antracen	**< 0.030**	mg/kg Ts	25%	ISO 18287:2008 mod	b)
Fluoranten	**< 0.030**	mg/kg Ts	25%	ISO 18287:2008 mod	b)
Pyren	**< 0.030**	mg/kg Ts	25%	ISO 18287:2008 mod	b)
Benzo(g,h,i)perylen	**< 0.030**	mg/kg Ts	25%	ISO 18287:2008 mod	b)
Summa PAH med låg molekylvikt	**< 0.045**	mg/kg Ts			b)
Summa PAH med medelhög molekylvikt	**< 0.075**	mg/kg Ts			b)
Summa PAH med hög molekylvikt	**< 0.11**	mg/kg Ts			b)
Summa cancerogena PAH	**< 0.090**	mg/kg Ts			b)
Summa övriga PAH	**< 0.14**	mg/kg Ts			b)
Summa totala PAH16	**< 0.23**	mg/kg Ts			b)
PCB 28	**< 0.0020**	mg/kg Ts	30%	EN 16167:2012 mod	b)
PCB 52	**< 0.0020**	mg/kg Ts	25%	EN 16167:2012 mod	b)
PCB 101	**< 0.0020**	mg/kg Ts	25%	EN 16167:2012 mod	b)
PCB 118	**< 0.0020**	mg/kg Ts	25%	EN 16167:2012 mod	b)
PCB 153	**< 0.0020**	mg/kg Ts	25%	EN 16167:2012 mod	b)
PCB 138	**< 0.0020**	mg/kg Ts	25%	EN 16167:2012 mod	b)
PCB 180	**< 0.0020**	mg/kg Ts	25%	EN 16167:2012 mod	b)
S:a PCB (7st)	**< 0.0070**	mg/kg Ts		EN 16167:2012 mod	b)
Totalkväve (Kjeldahl+dewardas)	**1100**	mg/kg	10%	SS 028101	a)
Totalkväve (Kjeldahl+dewardas)	**0.16**	% Ts	20%	Beräknad från analyserad halt	b)
Arsenik As	**< 2.7**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Barium Ba	**59**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Bly Pb	**9.6**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Fosfor P	**580**	mg/kg Ts	20%	SS028311 / ICP-AES	b)
Kadmium Cd	**< 0.20**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Kobolt Co	**4.9**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Koppar Cu	**8.7**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Krom Cr	**7.6**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Kvicksilver Hg	**0.028**	mg/kg Ts	20%	SS028311mod/SS-EN ISO17852mod	b)
Nickel Ni	**4.4**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Vanadin V	**16**	mg/kg Ts	25%	EN ISO 11885:2009 / SS 028311 utg 1	b)
Zink Zn	**48**	mg/kg Ts	25%	EN ISO 11885:2009 / SS	b)

Förklaringar

Laboratoriet/laboratorierna är ackrediterade av respektive lands ackrediteringsorgan. Ej ackrediterade analyser är markerade med *

Mätosäkerheten, om inget annat anges, redovisas som utvidgad mätosäkerhet med täckningsfaktor 2. Undantag relaterat till analyser utförda utanför Sverige kan förekomma. Ytterligare upplysningar samt mätosäkerhet och detektionsnivåer för mikrobiologiska analyser lämnas på begäran.

Denna rapport får endast återges i sin helhet, om inte utförande laboratorium i förväg skriftligen godkänt annat. Resultaten relaterar endast till det insända provet.

				028311 utg 1	
Diklormetan	**< 0.0050**	mg/kg Ts	30%	EPA 5021	b)
Triklormetan	**< 0.0050**	mg/kg Ts	25%	EPA 5021	b)
Tetraklormetan	**< 0.0050**	mg/kg Ts	25%	EPA 5021	b)
1,1,2-Trikloreten	**< 0.0050**	mg/kg Ts	20%	EPA 5021	b)
Tetrakloreten	**< 0.0050**	mg/kg Ts	20%	EPA 5021	b)
1,1-Dikloretan	**< 0.0050**	mg/kg Ts	30%	EPA 5021	b)
1,2-Dikloretan	**< 0.0050**	mg/kg Ts	25%	EPA 5021	b)
1,1,1-Trikloretan	**< 0.0050**	mg/kg Ts	25%	EPA 5021	b)
1,1,2-Trikloretan	**< 0.0050**	mg/kg Ts	30%	EPA 5021	b)
cis-1,2-Dikloreten	**< 0.0050**	mg/kg Ts	30%	EPA 5021	b)
trans-1,2-Dikloreten	**< 0.0050**	mg/kg Ts	30%	EPA 5021	b)
Vinylklorid	**< 0.0050**	mg/kg Ts	25%	EPA 5021	b)

Utförande laboratorium/underleverantör:

a) Eurofins Food & Feed Testing Sweden (Lidköping), SWEDEN, ISO/IEC 17025:2005 SWEDAC 1977
b) Eurofins Environment Testing Sweden AB, SWEDEN, ISO/IEC 17025:2005 SWEDAC 1125

Gustav Stenhammar, Rapportansvarig

Denna rapport är elektroniskt signerad.

Ackred. nr 1125
Provning
ISO/IEC 17025

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AR-20-SL-082861-01

EUSELI2-00742261
Kundnummer: SL8419231

Uppdragsmärkn.
Rösaberg

Analysrapport

Provnummer:	**177-2020-04010299**	Ankomsttemp °C Kem	11,0
Provbeskrivning:		Provtagningsdatum	2020-03-31
Matris:	Grundvatten	Provtagare	Lisa Westander
Provet ankom:	2020-03-31		
Utskriftsdatum:	2020-04-16		
Analyserna påbörjades:	2020-03-31		
Provmärkning:	PG1GW (PLW65-1)		
Provtagningsplats:	Rösaberga		

Analys	Resultat	Enhet	Mäto.	Metod/ref	
Bensen	**< 0.00050**	mg/l	30%	LidMiljö.0A.01.09	c)
Toluen	**< 0.0010**	mg/l	30%	LidMiljö.0A.01.09	c)
Etylbensen	**< 0.0010**	mg/l	30%	LidMiljö.0A.01.09	c)
M/P/O-Xylen	**< 0.0010**	mg/l	30%	LidMiljö.0A.01.09	c)
Summa TEX	**< 0.0020**	mg/l		LidMiljö.0A.01.09/15	c)
Alifater >C5-C8	**< 0.020**	mg/l	35%	SPI 2011	c)
Alifater >C8-C10	**< 0.020**	mg/l	35%	SPI 2011	c)
Alifater >C10-C12	**< 0.020**	mg/l	20%	Intern metod	c)
Alifater >C5-C12	**< 0.030**	mg/l		Intern metod	c)
Alifater >C12-C16	**< 0.020**	mg/l	20%	Intern metod	c)
Alifater >C16-C35	**< 0.050**	mg/l	25%	Intern metod	c)
Alifater >C12-C35	**< 0.050**	mg/l		Intern metod	c)
Aromater >C8-C10	**< 0.010**	mg/l	30%	SPI 2011	c)
Aromater >C10-C16	**< 0.010**	mg/l	20%	Intern metod	c)
Aromater >C16-C35	**< 0.0050**	mg/l	25%	Intern metod	c)
Oljetyp < C10	**Utgår**				c)*
Oljetyp > C10	**Utgår**				c)*
Bens(a)antracen	**< 0.010**	µg/l	25%	Intern metod	c)
Krysen	**< 0.010**	µg/l	25%	Intern metod	c)
Benso(b,k)fluoranten	**< 0.020**	µg/l	25%	Intern metod	c)
Benso(a)pyren	**< 0.010**	µg/l	30%	Intern metod	c)
Indeno(1,2,3-cd)pyren	**< 0.010**	µg/l	30%	Intern metod	c)
Dibens(a,h)antracen	**< 0.010**	µg/l	30%	Intern metod	c)
Summa cancerogena PAH	**< 0.20**	µg/l		Intern metod	c)
Naftalen	**0.12**	µg/l	30%	Intern metod	c)
Acenaftylen	**< 0.010**	µg/l	25%	Intern metod	c)

Förklaringar

Laboratoriet/laboratorierna är ackrediterade av respektive lands ackrediteringsorgan. Ej ackrediterade analyser är markerade med *

Mätosäkerheten, om inget annat anges, redovisas som utvidgad mätosäkerhet med täckningsfaktor 2. Undantag relaterat till analyser utförda utanför Sverige kan förekomma. Ytterligare upplysningar samt mätosäkerhet och detektionsnivåer för mikrobiologiska analyser lämnas på begäran.
Denna rapport får endast återges i sin helhet, om inte utförande laboratorium i förväg skriftligen godkänt annat. Resultaten relaterar endast till det insända provet.

Acenaften	**< 0.010**	µg/l	25%	Intern metod	c)
Fluoren	**< 0.010**	µg/l	25%	Intern metod	c)
Fenantren	**< 0.010**	µg/l	25%	Intern metod	c)
Antracen	**< 0.010**	µg/l	25%	Intern metod	c)
Fluoranten	**0.013**	µg/l	25%	Intern metod	c)
Pyren	**0.012**	µg/l	25%	Intern metod	c)
Benso(g,h,i)perylen	**< 0.010**	µg/l	30%	Intern metod	c)
Summa övriga PAH	**< 0.30**	µg/l		Intern metod	c)
Summa PAH med låg molekylvikt	**< 0.20**	µg/l		Intern metod	c)
Summa PAH med medelhög molekylvikt	**< 0.30**	µg/l		Intern metod	c)
Summa PAH med hög molekylvikt	**< 0.30**	µg/l		Intern metod	c)
PCB 28	**< 0.010**	µg/l	40%	Intern metod	c)
PCB 52	**< 0.010**	µg/l	40%	Intern metod	c)
PCB 101	**< 0.010**	µg/l	40%	Intern metod	c)
PCB 118	**< 0.010**	µg/l	40%	Intern metod	c)
PCB 138	**< 0.010**	µg/l	40%	Intern metod	c)
PCB 153	**< 0.010**	µg/l	40%	Intern metod	c)
PCB 180	**< 0.010**	µg/l	40%	Intern metod	c)
S:a PCB (7st)	**ND**			Intern metod	c)
pH	**6.2**		0.2	SS-EN ISO 10523:2012	b)
Temperatur vid pH-mätning	**20.2**	°C		SS-EN ISO 10523:2012	b)
Fosfor P	**0.53**	mg/l	10%	SS-EN ISO 15681-2:2005	b)
Kväve-N	**4.7**	mg/l	10%	ISO 29441:2010	b)
Arsenik As (filtrerat)	**0.0027**	mg/l	20%	EN ISO 17294-2:2016	c)
Barium Ba (filtrerat)	**0.14**	mg/l	25%	EN ISO 17294-2:2016	c)
Bly Pb (filtrerat)	**0.00083**	mg/l	20%	EN ISO 17294-2:2016	c)
Kadmium Cd (filtrerat)	**0.000099**	mg/l	20%	EN ISO 17294-2:2016	c)
Kobolt Co (filtrerat)	**0.0082**	mg/l	20%	EN ISO 17294-2:2016	c)
Koppar Cu (filtrerat)	**0.0054**	mg/l	25%	EN ISO 17294-2:2016	c)
Krom Cr (filtrerat)	**0.00094**	mg/l	20%	EN ISO 17294-2:2016	c)
Kvicksilver Hg (filtrerat)	**< 0.00010**	mg/l	20%	SS-EN ISO 17852:2008 mod	c)
Nickel Ni (filtrerat)	**0.0032**	mg/l	20%	EN ISO 17294-2:2016	c)
Vanadin V (filtrerat)	**0.00089**	mg/l	20%	EN ISO 17294-2:2016	c)
Zink Zn (filtrerat)	**0.034**	mg/l	25%	EN ISO 17294-2:2016	c)
Glyfosat	**<0.010**	µg/l	13%	Anal Bioanal Chem (2008) 391:2265-2276 mod.	a)
AMPA	**<0.010**	µg/l	13%	Anal Bioanal Chem (2008) 391:2265-2276 mod.	a)
Atrazine	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Atrazine-desethyl	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Atrazine-desisopropyl	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Atrazin-2-hydroxy	**<0.010**	µg/l	25%	Enviromental Science &	a)

Förklaringar

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				Technology vol.31,no 2 mod.	
Bentazone	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Cyanazine	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
2,6-Diklorbenzamid	**0.040**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
D -2,4	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Diclorprop	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Diuron	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Fluroxypyr	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Imidacloprid	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Isoproturon	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Klopyralid	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Kvinmerac	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
MCPA	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Mekoprop	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Metazaklor	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Terbuthylazine	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Diklormetan	**< 0.10**	µg/l	30%	Intern metod	c)
Pirimicarb	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Propyzamide	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Terbutylazin-2-hydroxy	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Terbutylazin-desetyl	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Triklormetan	**< 0.10**	µg/l	25%	Intern metod	c)

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Tetraklormetan	**< 0.10**	µg/l	25%	Intern metod	c)
Trikloreten	**< 0.10**	µg/l	20%	Intern metod	c)
Tetrakloreten	**< 0.10**	µg/l		Intern metod	c)
1,1-Dikloretan	**< 0.10**	µg/l	30%	Intern metod	c)
1,2-Dikloretan	**< 0.10**	µg/l	25%	Intern metod	c)
1,1,1-Trikloretan	**< 0.10**	µg/l	25%	Intern metod	c)
1,1,2-Trikloretan	**< 0.10**	µg/l	30%	Intern metod	c)
cis-1,2-Dikloreten	**< 0.10**	µg/l	30%	Intern metod	c)
trans-1,2-Dikloreten	**< 0.10**	µg/l	30%	Intern metod	c)
1,1-Dikloreten	**< 0.10**	µg/l	30%	Intern metod	c)
Vinylklorid	**< 0.10**	µg/l	25%	Intern metod	c)

Utförande laboratorium/underleverantör:

a) Eurofins Food & Feed Testing Sweden (Lidköping), SWEDEN, ISO/IEC 17025:2005 SWEDAC 1977
b) Eurofins Water Testing Sweden, SWEDEN, ISO/IEC 17025:2005 SWEDAC 10300
c) Eurofins Environment Testing Sweden AB, SWEDEN, ISO/IEC 17025:2005 SWEDAC 1125

Sara Gustavsson, Rapportansvarig

Denna rapport är elektroniskt signerad.

Förklaringar

AR-003v55

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SWEDAC ACKREDITERING
Ackred. nr 1125
Provning
ISO/IEC 17025

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AR-20-SL-082862-01

EUSELI2-00742261
Kundnummer: SL8419231

Uppdragsmärkn.
Rösaberg

Analysrapport

Provnummer:	**177-2020-04010300**	Ankomsttemp °C Kem	11,0
Provbeskrivning:		Provtagningsdatum	2020-03-31
		Provtagare	Lisa Westander
Matris:	Grundvatten		
Provet ankom:	2020-03-31		
Utskriftsdatum:	2020-04-16		
Analyserna påbörjades:	2020-03-31		
Provmärkning:	PG2GW (PLW65-1)		
Provtagningsplats:	Rösaberga		

Analys	Resultat	Enhet	Mäto.	Metod/ref	
Bensen	**< 0.00050**	mg/l	30%	LidMiljö.0A.01.09	c)
Toluen	**< 0.0010**	mg/l	30%	LidMiljö.0A.01.09	c)
Etylbensen	**< 0.0010**	mg/l	30%	LidMiljö.0A.01.09	c)
M/P/O-Xylen	**< 0.0010**	mg/l	30%	LidMiljö.0A.01.09	c)
Summa TEX	**< 0.0020**	mg/l		LidMiljö.0A.01.09/15	c)
Alifater >C5-C8	**< 0.020**	mg/l	35%	SPI 2011	c)
Alifater >C8-C10	**< 0.020**	mg/l	35%	SPI 2011	c)
Alifater >C10-C12	**< 0.020**	mg/l	20%	Intern metod	c)
Alifater >C5-C12	**< 0.030**	mg/l		Intern metod	c)
Alifater >C12-C16	**< 0.020**	mg/l	20%	Intern metod	c)
Alifater >C16-C35	**< 0.050**	mg/l	25%	Intern metod	c)
Alifater >C12-C35	**< 0.050**	mg/l		Intern metod	c)
Aromater >C8-C10	**< 0.010**	mg/l	30%	SPI 2011	c)
Aromater >C10-C16	**< 0.010**	mg/l	20%	Intern metod	c)
Aromater >C16-C35	**< 0.0050**	mg/l	25%	Intern metod	c)
Oljetyp < C10	**Utgår**				c)*
Oljetyp > C10	**Utgår**				c)*
Bens(a)antracen	**0.013**	µg/l	25%	Intern metod	c)
Krysen	**0.011**	µg/l	25%	Intern metod	c)
Benso(b,k)fluoranten	**0.024**	µg/l	25%	Intern metod	c)
Benso(a)pyren	**0.011**	µg/l	30%	Intern metod	c)
Indeno(1,2,3-cd)pyren	**< 0.010**	µg/l	30%	Intern metod	c)
Dibens(a,h)antracen	**< 0.010**	µg/l	30%	Intern metod	c)
Summa cancerogena PAH	**< 0.20**	µg/l		Intern metod	c)
Naftalen	**0.043**	µg/l	30%	Intern metod	c)
Acenaftylen	**< 0.010**	µg/l	25%	Intern metod	c)

Förklaringar

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Mätosäkerheten, om inget annat anges, redovisas som utvidgad mätosäkerhet med täckningsfaktor 2. Undantag relaterat till analyser utförda utanför Sverige kan förekomma. Ytterligare upplysningar samt mätosäkerhet och detektionsnivåer för mikrobiologiska analyser lämnas på begäran.

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Acenaften	**< 0.010**	µg/l	25%	Intern metod	c)
Fluoren	**< 0.010**	µg/l	25%	Intern metod	c)
Fenantren	**0.013**	µg/l	25%	Intern metod	c)
Antracen	**< 0.010**	µg/l	25%	Intern metod	c)
Fluoranten	**0.023**	µg/l	25%	Intern metod	c)
Pyren	**0.019**	µg/l	25%	Intern metod	c)
Benso(g,h,i)perylen	**< 0.010**	µg/l	30%	Intern metod	c)
Summa övriga PAH	**< 0.30**	µg/l		Intern metod	c)
Summa PAH med låg molekylvikt	**< 0.20**	µg/l		Intern metod	c)
Summa PAH med medelhög molekylvikt	**< 0.30**	µg/l		Intern metod	c)
Summa PAH med hög molekylvikt	**< 0.30**	µg/l		Intern metod	c)
PCB 28	**< 0.020**	µg/l	40%	Intern metod	c)
PCB 52	**< 0.020**	µg/l	40%	Intern metod	c)
PCB 101	**< 0.020**	µg/l	40%	Intern metod	c)
PCB 118	**< 0.020**	µg/l	40%	Intern metod	c)
PCB 138	**< 0.020**	µg/l	40%	Intern metod	c)
PCB 153	**< 0.020**	µg/l	40%	Intern metod	c)
PCB 180	**< 0.020**	µg/l	40%	Intern metod	c)
S:a PCB (7st)	**ND**			Intern metod	c)
pH	**6.3**		0.2	SS-EN ISO 10523:2012	b)
Temperatur vid pH-mätning	**22.5**	°C		SS-EN ISO 10523:2012	b)
Fosfor P	**0.47**	mg/l	10%	SS-EN ISO 15681-2:2005	b)
Kväve-N	**4.3**	mg/l	10%	ISO 29441:2010	b)
Arsenik As (filtrerat)	**0.0013**	mg/l	20%	EN ISO 17294-2:2016	c)
Barium Ba (filtrerat)	**0.14**	mg/l	25%	EN ISO 17294-2:2016	c)
Bly Pb (filtrerat)	**0.0012**	mg/l	20%	EN ISO 17294-2:2016	c)
Kadmium Cd (filtrerat)	**0.00012**	mg/l	20%	EN ISO 17294-2:2016	c)
Kobolt Co (filtrerat)	**0.0057**	mg/l	20%	EN ISO 17294-2:2016	c)
Koppar Cu (filtrerat)	**0.0084**	mg/l	25%	EN ISO 17294-2:2016	c)
Krom Cr (filtrerat)	**0.00092**	mg/l	20%	EN ISO 17294-2:2016	c)
Kvicksilver Hg (filtrerat)	**< 0.00010**	mg/l	20%	SS-EN ISO 17852:2008 mod	c)
Nickel Ni (filtrerat)	**0.0021**	mg/l	20%	EN ISO 17294-2:2016	c)
Vanadin V (filtrerat)	**0.0013**	mg/l	20%	EN ISO 17294-2:2016	c)
Zink Zn (filtrerat)	**0.050**	mg/l	25%	EN ISO 17294-2:2016	c)
Glyfosat	**<0.010**	µg/l	13%	Anal Bioanal Chem (2008) 391:2265-2276 mod.	a)
AMPA	**<0.010**	µg/l	13%	Anal Bioanal Chem (2008) 391:2265-2276 mod.	a)
Atrazine	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Atrazine-desethyl	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Atrazine-desisopropyl	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Atrazin-2-hydroxy	**<0.010**	µg/l	25%	Enviromental Science &	a)

Förklaringar

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				Technology vol.31,no 2 mod.	
Bentazone	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Cyanazine	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
2,6-Diklorbenzamid	**0.060**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
D -2,4	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Diclorprop	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Diuron	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Fluroxypyr	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Imidacloprid	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Isoproturon	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Klopyralid	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Kvinmerac	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
MCPA	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Mekoprop	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Metazaklor	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Terbuthylazine	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Diklormetan	**< 0.10**	µg/l	30%	Intern metod	c)
Pirimicarb	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Propyzamide	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Terbutylazin-2-hydroxy	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Terbutylazin-desetyl	**<0.010**	µg/l	25%	Enviromental Science & Technology vol.31,no 2 mod.	a)
Triklormetan	**< 0.10**	µg/l	25%	Intern metod	c)

Förklaringar

Laboratoriet/laboratorierna är ackrediterade av respektive lands ackrediteringsorgan. Ej ackrediterade analyser är markerade med *

Mätosäkerheten, om inget annat anges, redovisas som utvidgad mätosäkerhet med täckningsfaktor 2. Undantag relaterat till analyser utförda utanför Sverige kan förekomma. Ytterligare upplysningar samt mätosäkerhet och detektionsnivåer för mikrobiologiska analyser lämnas på begäran.

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Tetraklormetan	**< 0.10**	µg/l	25%	Intern metod	c)
Trikloreten	**< 0.10**	µg/l	20%	Intern metod	c)
Tetrakloreten	**< 0.10**	µg/l		Intern metod	c)
1,1-Dikloretan	**< 0.10**	µg/l	30%	Intern metod	c)
1,2-Dikloretan	**< 0.10**	µg/l	25%	Intern metod	c)
1,1,1-Trikloretan	**< 0.10**	µg/l	25%	Intern metod	c)
1,1,2-Trikloretan	**< 0.10**	µg/l	30%	Intern metod	c)
cis-1,2-Dikloreten	**< 0.10**	µg/l	30%	Intern metod	c)
trans-1,2-Dikloreten	**< 0.10**	µg/l	30%	Intern metod	c)
1,1-Dikloreten	**< 0.10**	µg/l	30%	Intern metod	c)
Vinylklorid	**< 0.10**	µg/l	25%	Intern metod	c)

Kemisk kommentar
Höjd rapporteringsgräns för PCB på grund av svår matris.

Utförande laboratorium/underleverantör:

a) Eurofins Food & Feed Testing Sweden (Lidköping), SWEDEN, ISO/IEC 17025:2005 SWEDAC 1977
b) Eurofins Water Testing Sweden, SWEDEN, ISO/IEC 17025:2005 SWEDAC 10300
c) Eurofins Environment Testing Sweden AB, SWEDEN, ISO/IEC 17025:2005 SWEDAC 1125

Sara Gustavsson, Rapportansvarig

Denna rapport är elektroniskt signerad.

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AR-20-SL-086171-01

EUSELI2-00742261
Kundnummer: SL8419231

Uppdragsmärkn.
Rösaberg

Analysrapport

Provnummer:	**177-2020-04010301**	Ankomsttemp °C Kem	11,0
Provbeskrivning:		Provtagningsdatum	2020-03-31
Matris:	Grundvatten	Provtagare	Lisa Westander
Provet ankom:	2020-03-31		
Utskriftsdatum:	2020-04-20		
Analyserna påbörjades:	2020-03-31		
Provmärkning:	PG3GW		
Provtagningsplats:	Rösaberga		

Analys	Resultat	Enhet	Mäto.	Metod/ref	
Bensen	**< 0.00050**	mg/l	30%	LidMiljö.0A.01.09	b)
Toluen	**< 0.0010**	mg/l	30%	LidMiljö.0A.01.09	b)
Etylbensen	**< 0.0010**	mg/l	30%	LidMiljö.0A.01.09	b)
M/P/O-Xylen	**< 0.0010**	mg/l	30%	LidMiljö.0A.01.09	b)
Summa TEX	**< 0.0020**	mg/l		LidMiljö.0A.01.09/15	b)
Alifater >C5-C8	**< 0.020**	mg/l	35%	SPI 2011	b)
Alifater >C8-C10	**< 0.020**	mg/l	35%	SPI 2011	b)
Alifater >C10-C12	**< 0.020**	mg/l	20%	Intern metod	b)
Alifater >C5-C12	**< 0.030**	mg/l		Intern metod	b)
Alifater >C12-C16	**< 0.020**	mg/l	20%	Intern metod	b)
Alifater >C16-C35	**< 0.050**	mg/l	25%	Intern metod	b)
Alifater >C12-C35	**< 0.050**	mg/l		Intern metod	b)
Aromater >C8-C10	**< 0.010**	mg/l	30%	SPI 2011	b)
Aromater >C10-C16	**< 0.010**	mg/l	20%	Intern metod	b)
Aromater >C16-C35	**< 0.0050**	mg/l	25%	Intern metod	b)
Oljetyp < C10	**Utgår**				b)*
Oljetyp > C10	**Utgår**				b)*
Bens(a)antracen	**< 0.010**	µg/l	25%	Intern metod	b)
Krysen	**< 0.010**	µg/l	25%	Intern metod	b)
Benso(b,k)fluoranten	**< 0.020**	µg/l	25%	Intern metod	b)
Benso(a)pyren	**< 0.010**	µg/l	30%	Intern metod	b)
Indeno(1,2,3-cd)pyren	**< 0.010**	µg/l	30%	Intern metod	b)
Dibens(a,h)antracen	**< 0.010**	µg/l	30%	Intern metod	b)
Summa cancerogena PAH	**< 0.20**	µg/l		Intern metod	b)
Naftalen	**0.023**	µg/l	30%	Intern metod	b)
Acenaftylen	**< 0.010**	µg/l	25%	Intern metod	b)

Förklaringar

Laboratoriet/laboratorierna är ackrediterade av respektive lands ackrediteringsorgan. Ej ackrediterade analyser är markerade med *

Mätosäkerheten, om inget annat anges, redovisas som utvidgad mätosäkerhet med täckningsfaktor 2. Undantag relaterat till analyser utförda utanför Sverige kan förekomma. Ytterligare upplysningar samt mätosäkerhet och detektionsnivåer för mikrobiologiska analyser lämnas på begäran.

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Acenaften	**< 0.010**	µg/l	25%	Intern metod	b)
Fluoren	**< 0.010**	µg/l	25%	Intern metod	b)
Fenantren	**< 0.010**	µg/l	25%	Intern metod	b)
Antracen	**< 0.010**	µg/l	25%	Intern metod	b)
Fluoranten	**< 0.010**	µg/l	25%	Intern metod	b)
Pyren	**< 0.010**	µg/l	25%	Intern metod	b)
Benso(g,h,i)perylen	**< 0.010**	µg/l	30%	Intern metod	b)
Summa övriga PAH	**< 0.30**	µg/l		Intern metod	b)
Summa PAH med låg molekylvikt	**< 0.20**	µg/l		Intern metod	b)
Summa PAH med medelhög molekylvikt	**< 0.30**	µg/l		Intern metod	b)
Summa PAH med hög molekylvikt	**< 0.30**	µg/l		Intern metod	b)
PCB 28	**< 0.020**	µg/l	40%	Intern metod	b)
PCB 52	**< 0.020**	µg/l	40%	Intern metod	b)
PCB 101	**< 0.020**	µg/l	40%	Intern metod	b)
PCB 118	**< 0.020**	µg/l	40%	Intern metod	b)
PCB 138	**< 0.020**	µg/l	40%	Intern metod	b)
PCB 153	**< 0.020**	µg/l	40%	Intern metod	b)
PCB 180	**< 0.020**	µg/l	40%	Intern metod	b)
S:a PCB (7st)	**ND**			Intern metod	b)
pH	**6.9**		0.2	SS-EN ISO 10523:2012	a)
Temperatur vid pH-mätning	**20.7**	°C		SS-EN ISO 10523:2012	a)
Fosfor P	**0.65**	mg/l	10%	SS-EN ISO 15681-2:2005	a)
Kväve-N	**4.0**	mg/l	10%	ISO 29441:2010	a)
Arsenik As (filtrerat)	**0.0015**	mg/l	20%	EN ISO 17294-2:2016	b)
Barium Ba (filtrerat)	**0.13**	mg/l	25%	EN ISO 17294-2:2016	b)
Bly Pb (filtrerat)	**0.000095**	mg/l	20%	EN ISO 17294-2:2016	b)
Kadmium Cd (filtrerat)	**0.000010**	mg/l	20%	EN ISO 17294-2:2016	b)
Kobolt Co (filtrerat)	**0.0035**	mg/l	20%	EN ISO 17294-2:2016	b)
Koppar Cu (filtrerat)	**0.0018**	mg/l	25%	EN ISO 17294-2:2016	b)
Krom Cr (filtrerat)	**0.00045**	mg/l	20%	EN ISO 17294-2:2016	b)
Kvicksilver Hg (filtrerat)	**< 0.00010**	mg/l	20%	SS-EN ISO 17852:2008 mod	b)
Nickel Ni (filtrerat)	**0.0045**	mg/l	20%	EN ISO 17294-2:2016	b)
Vanadin V (filtrerat)	**0.00060**	mg/l	20%	EN ISO 17294-2:2016	b)
Zink Zn (filtrerat)	**0.028**	mg/l	25%	EN ISO 17294-2:2016	b)
Diklormetan	**< 0.10**	µg/l	30%	Intern metod	b)
Triklormetan	**< 0.10**	µg/l	25%	Intern metod	b)
Tetraklormetan	**< 0.10**	µg/l	25%	Intern metod	b)
Trikloreten	**< 0.10**	µg/l	20%	Intern metod	b)
Tetrakloreten	**< 0.10**	µg/l		Intern metod	b)
1,1-Dikloretan	**< 0.10**	µg/l	30%	Intern metod	b)
1,2-Dikloretan	**< 0.10**	µg/l	25%	Intern metod	b)
1,1,1-Trikloretan	**< 0.10**	µg/l	25%	Intern metod	b)
1,1,2-Trikloretan	**< 0.10**	µg/l	30%	Intern metod	b)
cis-1,2-Dikloreten	**< 0.10**	µg/l	30%	Intern metod	b)

trans-1,2-Dikloreten	**< 0.10**	µg/l	30%	Intern metod	b)
1,1-Dikloreten	**< 0.10**	µg/l	30%	Intern metod	b)
Vinylklorid	**< 0.10**	µg/l	25%	Intern metod	b)
Kemisk kommentar Höjd rapporteringsgräns för PCB på grund av svår matris.					

Utförande laboratorium/underleverantör:

a) Eurofins Water Testing Sweden, SWEDEN, ISO/IEC 17025:2005 SWEDAC 10300
b) Eurofins Environment Testing Sweden AB, SWEDEN, ISO/IEC 17025:2005 SWEDAC 1125

Paola Nilson, Rapportansvarig

Denna rapport är elektroniskt signerad.

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EUSELI2-00742591
Kundnummer: SL8419231

Uppdragsmärkn.
Röseberga

Analysrapport

Provnummer:	**177-2020-04011412**	Ankomsttemp °C Kem	10
Provbeskrivning:		Provtagningsdatum	2020-03-25
Matris:	Grundvatten	Provtagare	Lisa Westander
Provet ankom:	2020-04-01		
Utskriftsdatum:	2020-04-16		
Analyserna påbörjades:	2020-04-01		
Provmärkning:	PG5		

Analys	Resultat	Enhet	Mäto.	Metod/ref	
Bensen	**< 0.00050**	mg/l	30%	LidMiljö.0A.01.09	b)
Toluen	**< 0.0010**	mg/l	30%	LidMiljö.0A.01.09	b)
Etylbensen	**< 0.0010**	mg/l	30%	LidMiljö.0A.01.09	b)
M/P/O-Xylen	**< 0.0010**	mg/l	30%	LidMiljö.0A.01.09	b)
Summa TEX	**< 0.0020**	mg/l		LidMiljö.0A.01.09/15	b)
Alifater >C5-C8	**< 0.020**	mg/l	35%	SPI 2011	b)
Alifater >C8-C10	**< 0.020**	mg/l	35%	SPI 2011	b)
Alifater >C10-C12	**< 0.020**	mg/l	20%	Intern metod	b)
Alifater >C5-C12	**< 0.030**	mg/l		Intern metod	b)
Alifater >C12-C16	**< 0.020**	mg/l	20%	Intern metod	b)
Alifater >C16-C35	**< 0.050**	mg/l	25%	Intern metod	b)
Alifater >C12-C35	**< 0.050**	mg/l		Intern metod	b)
Aromater >C8-C10	**< 0.010**	mg/l	30%	SPI 2011	b)
Aromater >C10-C16	**< 0.010**	mg/l	20%	Intern metod	b)
Aromater >C16-C35	**< 0.0050**	mg/l	25%	Intern metod	b)
Oljetyp < C10	**Utgår**				b)*
Oljetyp > C10	**Utgår**				b)*
pH	**5.9**		0.2	SS-EN ISO 10523:2012	a)
Temperatur vid pH-mätning	**20.9**	°C		SS-EN ISO 10523:2012	a)
Fosfor P	**12**	mg/l	10%	SS-EN ISO 15681-2:2005	a)
Kväve-N	**53**	mg/l	10%	ISO 29441:2010	a)
Arsenik As (filtrerat)	**0.00054**	mg/l	20%	EN ISO 17294-2:2016	b)
Barium Ba (filtrerat)	**0.20**	mg/l	25%	EN ISO 17294-2:2016	b)
Bly Pb (filtrerat)	**0.000034**	mg/l	20%	EN ISO 17294-2:2016	b)
Kadmium Cd (filtrerat)	**0.000028**	mg/l	20%	EN ISO 17294-2:2016	b)
Kobolt Co (filtrerat)	**0.0041**	mg/l	20%	EN ISO 17294-2:2016	b)
Koppar Cu (filtrerat)	**0.0023**	mg/l	25%	EN ISO 17294-2:2016	b)

Förklaringar

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Krom Cr (filtrerat)	**0.00045**	mg/l	20%	EN ISO 17294-2:2016	b)
Kvicksilver Hg (filtrerat)	**< 0.00010**	mg/l	20%	SS-EN ISO 17852:2008 mod	b)
Nickel Ni (filtrerat)	**0.00066**	mg/l	20%	EN ISO 17294-2:2016	b)
Vanadin V (filtrerat)	**0.00015**	mg/l	20%	EN ISO 17294-2:2016	b)
Zink Zn (filtrerat)	**0.0040**	mg/l	25%	EN ISO 17294-2:2016	b)

Utförande laboratorium/underleverantör:

a) Eurofins Water Testing Sweden, SWEDEN, ISO/IEC 17025:2005 SWEDAC 10300
b) Eurofins Environment Testing Sweden AB, SWEDEN, ISO/IEC 17025:2005 SWEDAC 1125

Sara Gustavsson, Rapportansvarig

Denna rapport är elektroniskt signerad.

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EUSELI2-00742591
Kundnummer: SL8419231

Uppdragsmärkn.
Röseberga

Analysrapport

Provnummer: **177-2020-04011413**
Provbeskrivning:
Matris: Grundvatten
Provet ankom: 2020-04-01
Utskriftsdatum: 2020-04-16
Analyserna påbörjades: 2020-04-01
Provmärkning: PG8

Analys	Resultat	Enhet	Mäto.	Metod/ref	
Bens(a)antracen	**0.095**	µg/l	25%	Intern metod	b)
Krysen	**0.097**	µg/l	25%	Intern metod	b)
Benso(b,k)fluoranten	**0.17**	µg/l	25%	Intern metod	b)
Benso(a)pyren	**0.12**	µg/l	30%	Intern metod	b)
Indeno(1,2,3-cd)pyren	**0.056**	µg/l	30%	Intern metod	b)
Dibens(a,h)antracen	**0.011**	µg/l	30%	Intern metod	b)
Summa cancerogena PAH	**0.56**	µg/l		Intern metod	b)
Naftalen	**0.056**	µg/l	30%	Intern metod	b)
Acenaftylen	**< 0.010**	µg/l	25%	Intern metod	b)
Acenaften	**0.049**	µg/l	25%	Intern metod	b)
Fluoren	**0.080**	µg/l	25%	Intern metod	b)
Fenantren	**0.31**	µg/l	25%	Intern metod	b)
Antracen	**0.037**	µg/l	25%	Intern metod	b)
Fluoranten	**0.32**	µg/l	25%	Intern metod	b)
Pyren	**0.27**	µg/l	25%	Intern metod	b)
Benso(g,h,i)perylen	**0.037**	µg/l	30%	Intern metod	b)
Summa övriga PAH	**1.2**	µg/l		Intern metod	b)
Summa PAH med låg molekylvikt	**< 0.20**	µg/l		Intern metod	b)
Summa PAH med medelhög molekylvikt	**1.0**	µg/l		Intern metod	b)
Summa PAH med hög molekylvikt	**0.59**	µg/l		Intern metod	b)
pH	**6.2**		0.2	SS-EN ISO 10523:2012	a)
Temperatur vid pH-mätning	**21.0**	°C		SS-EN ISO 10523:2012	a)
Fosfor P	**61**	mg/l	10%	SS-EN ISO 15681-2:2005	a)
Kväve-N	**110**	mg/l	10%	ISO 29441:2010	a)
Arsenik As (filtrerat)	**0.0011**	mg/l	20%	EN ISO 17294-2:2016	b)
Barium Ba (filtrerat)	**0.14**	mg/l	25%	EN ISO 17294-2:2016	b)
Bly Pb (filtrerat)	**0.00045**	mg/l	20%	EN ISO 17294-2:2016	b)

Förklaringar

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Mätosäkerheten, om inget annat anges, redovisas som utvidgad mätosäkerhet med täckningsfaktor 2. Undantag relaterat till analyser utförda utanför Sverige kan förekomma. Ytterligare upplysningar samt mätosäkerhet och detektionsnivåer för mikrobiologiska analyser lämnas på begäran.

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Kadmium Cd (filtrerat)	**0.000025**	mg/l	20%	EN ISO 17294-2:2016	b)
Kobolt Co (filtrerat)	**0.0036**	mg/l	20%	EN ISO 17294-2:2016	b)
Koppar Cu (filtrerat)	**0.0038**	mg/l	25%	EN ISO 17294-2:2016	b)
Krom Cr (filtrerat)	**0.00061**	mg/l	20%	EN ISO 17294-2:2016	b)
Kvicksilver Hg (filtrerat)	**< 0.00010**	mg/l	20%	SS-EN ISO 17852:2008 mod	b)
Nickel Ni (filtrerat)	**0.0012**	mg/l	20%	EN ISO 17294-2:2016	b)
Vanadin V (filtrerat)	**0.00072**	mg/l	20%	EN ISO 17294-2:2016	b)
Zink Zn (filtrerat)	**0.018**	mg/l	25%	EN ISO 17294-2:2016	b)

Utförande laboratorium/underleverantör:

a) Eurofins Water Testing Sweden, SWEDEN, ISO/IEC 17025:2005 SWEDAC 10300
b) Eurofins Environment Testing Sweden AB, SWEDEN, ISO/IEC 17025:2005 SWEDAC 1125

Sara Gustavsson, Rapportansvarig

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Förklaringar

Laboratoriet/laboratorierna är ackrediterade av respektive lands ackrediteringsorgan. Ej ackrediterade analyser är markerade med *

Mätosäkerheten, om inget annat anges, redovisas som utvidgad mätosäkerhet med täckningsfaktor 2. Undantag relaterat till analyser utförda utanför Sverige kan förekomma. Ytterligare upplysningar samt mätosäkerhet och detektionsnivåer för mikrobiologiska analyser lämnas på begäran.

Denna rapport får endast återges i sin helhet, om inte utförande laboratorium i förväg skriftligen godkänt annat. Resultaten relaterar endast till det insända provet.