

Survey of the emergence and use of naturally occurring materials



Nordic Council
of Ministers



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Foreword

The *Survey on the emergence and use of naturally occurring materials* was initiated in February 2021 and finished in August 2021. The project was funded through the Nordic Council of Ministers and the Nordic Working Group for Circular Economy (NCE).

The project work was followed by steering group with representatives from the Nordic Working Group for Circular Economy and consisted of the following members:

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Although there is a shared interest in the emergence and use of naturally occurring materials in the Nordic Working Group for Circular Economy (NCE) and the project group, points of views expressed in the survey are the authors.

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Project group

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Terms and definitions

C&D waste	Waste material, that is generated in construction or demolition activity.
Drill and blast excavation	A method of disintegrating rock by drilling small diameter holes on a planned layout, packing these with explosives and then firing to a fixed program to shatter the rock in a desired form (ITA-AITES, 2021).
Environmental quality standards	Environmental quality standards refer to legally binding limits for specific substances. They can be set as concentration in soil, groundwater, and air, and at a level where no adverse effect to the medium occurs.
EW-C-Stat	European Waste Classification for statistics.
Excavated masses	Excavated masses are typically generated with some type of excavator and consist of a mix of soil, decomposed bedrock, clay, silt, sand, gravel, stones etc.
Mechanically excavated material	Typically, rock masses, that are excavated by heavy cutting or digging equipment, such as tunnel boring machines, or by drilling and blasting activities in road or tunnel construction.
Muck	Excavated soil or rock that must be removed from the tunnel or shaft in order to continue advancing. The removal operation is termed "mucking" or "mucking out" (ITA-AITES, 2021)
Naturally occurring materials	For the scope of this project, naturally occurring materials are defined as natural mineral masses consisting of decomposed bedrock and crushed rock, such as clay, silt, sand, gravel, crushed stone, and other stone. In addition, mineral masses containing converted organic material, such as topsoil, bog soil and the like are included. Natural mineral masses that are excavated during building and construction projects as well as remediation in construction.
Nordic countries	In relation to the present project, it covers Denmark, Sweden, Norway, and Finland.
Polluted soil	Soil pollution refers to the presence of chemicals in soil (primarily but not exclusively human-made), in high enough concentrations to pose a risk to human health and/or ecosystem.
Risk assessment	Risk assessment refers to a process where environmental data are collected, organised, and analysed to estimate the risk of undesired effects on organisms, populations or ecosystems caused by various stressors associated with human activity.
Site-specific risk assessment	A site-specific risk assessment takes into account the relevant information and conditions at a specific site and for the specific project or application.
Soil	Soil refers to the immediate surface of the earth containing mineral or organic material that serves as a natural medium for the growth of land plants. Soil in this context includes soil and soil components down to the "bedrock".
Tunnel boring machine	Machines used for the mechanical excavation of tunnels.
WFD	Waste Framework Directive.

English	Danish	Swedish	Norwegian	Finnish
TBM – tunnel boring machine	Tunnelbore-maskine	Tunnelborr-maskin	Tunnelbore-maskin	Tunnelipora
Clay	Ler	Lera	Leire	Savi
Lime Cement Stabilized clay	Kalkstabiliseret/ cementstabiliseret ler	Kalkstabiliserad/ cementstabiliserad lera	Kalksementstabilisert leire	Kalkkisementti – stabiloitu savi
Silt	Silt	Silt	Silt	Siltti
Sand	Sand	Sand	Sand	Hiekka
Gravel	Grus	Grus	Pukk	Sora
Crushed stone	Knust sten	Krossad sten	Sprengstein	Murske, sepeli
Topsoil	Muldjord	Matjord	Matjord og vegetasjonsdekke	Pintamaa
Bogsoil	Mosejord	Myrmark	Myrjord	Suoturve
Peat	Tørv	Torv	Torv	Turve
Tree stump and roots	Træstube og træødder	Stubbar och rötter	Stubber og røtter	Kannot ja juuret
Sediment	Sediment	Sediment	Sedimenter	Sedimentti
Acid sulphate soil	Syresulfatjord	Sur sulfatjord	Sur sulfatjord	Hapan sulfaattimaa, alunamaa

Sammenfatning

Naturligt forekommende materialer repræsenterer et stort ressourcepotentiale - hvis de anvendes mere effektivt. Optimeret håndtering af materialerne forudsætter dog, at vi har kendskab til materialerne, muligt forureningsniveau, regulering i området og kendskab til potentielle barrierer og udfordringer i styringen af materialerne.

Flere forskellige slags materialer er dækket af udtrykket "naturligt forekommende materialer". Udgravning af disse materialer i byggeri og konstruktion kan ske på forskellige måder og ved hjælp af forskellige slags udstyr, der genererer materialer, der adskiller sig i kvalitet og egenskaber. Infrastrukturprojekter i Norge og Sverige, hvor geologien er domineret af klipper, kræver forskellige tilgange og udstyr sammenlignet med projekter, hvor materialerne består af en blanding af jord, nedbrudt grundfjeld, ler, silt, sand, grus osv., som kan udgraves med en gravemaskine. Kvaliteten af de materialer, der genereres ved de forskellige metoder, varierer med hensyn til partikelstørrelse, sammensætning og forureningsniveau. Derfor er det vigtigt at være i stand til at skelne mellem dem ved indsamling af information om mængder, samt i forhold til regulering, bedste praksis og udfordringer i styringen af materialerne.

Håndtering af naturligt forekommende materialer i de nordiske lande er reguleret af et komplekst sæt lovgivning, der er baseret på, men ikke eksklusiv, miljølovgivning, affaldslovgivning, jordlovgivning, arealanvendelse og bygningsbestemmelser. Forvaltningen af materialer kræver enten anmeldelse til myndighederne eller tilladelser. Selvom der findes specifik lovgivning om jord i alle lande, er der ingen enkelt, specifik lovgivning til styring af stenmasser fra hverken sprængning eller tunnelboreaktiviteter.

I alle nordiske lande findes der i forskellig grad underliggende sæt vejledningsdokumenter og håndbøger. Der arbejdes løbende med udvikling af retningslinjer. For eksempel, er svenske retningslinjer, håndbøger og andre juridiske dokumenter vedrørende håndtering af masser, biprodukter og affald under opdatering, herunder den svenske bygningslov, som er under revision. I Norge og Finland er ny lovgivning på vej, der har fokus på henholdsvis forvaltning af overskydende uforurenede materialer, der genereres i henholdsvis byggeaktiviteter, og forvaltning af uforurenede jord.

På grund af geografiske forskelle mellem de nordiske lande er der naturlige forskelle med hensyn til de typer og mængder af materialer, der skal håndteres i de nordiske lande. Kortlægningen af relevante materialer viste, at materialer såsom en blanding af jord og andre mineralmasser er den mest dominerende fraktion i Danmark og Finland, mens stenmasser fra bore- og sprængningsaktiviteter udgør betydelige mængder i Norge og Sverige. Der er væsentlige forskelle i mængden af naturligt forekommende materialer, der håndteres på årsbasis.

Baseret på de indsamlede oplysninger kan man sige, at der er et potentiale for optimeret håndtering af naturligt forekommende materialer i de nordiske lande. Baseret på de tilgængelige data og oplysninger er det imidlertid ikke muligt at give et kvantitativt skøn over, hvor stort dette potentiale er. Det skyldes, at de nationale affaldsstatistikker er et dårligt redskab til at give en detaljeret oversigt over mængder af materialer og deres håndtering i praksis og hverken afspejler de

forskellige materialetyper eller deres respektive geotekniske egenskaber. En anden årsag er, at materialer, som bruges på opgravningsstedet, typisk slet ikke er registreret. Derfor er det vanskeligt at få et godt overblik over vigtige materialestrømme, hvordan de styres, og hvor stort potentialet for optimeret styring er.

Klassificeringen af naturligt forekommende materialer som affald eller ikke-affald / ressource er af stor betydning for forvaltningen af materialerne. Klassificering som affald betyder ikke, at materialerne ikke må eller ikke kan bruges, de kan stadig nyttiggøres eller genanvendes. Klassificering som affald betyder imidlertid, at materialer er underlagt affaldsreglerne og de konsekvenser dette medfører for godkendelser, tilladelser, overholdelse af relevante grænseværdier, gebyrer og afgifter etc. Dette har stor indflydelse i praksis på tidsrammen for beslutninger som tilladelser eller godkendelser, hvilket igen har stor påvirkning på omkostninger og dermed valg og muligheder for materialehåndtering. Dette forudsætter, at entreprenørerne har tilstrækkelig viden og ekspertise til at kunne vurdere, om et materiale er affald eller ej i hver situation for at kunne ansøge om tilladelser eller hvad der måtte være relevant.

Den juridiske ramme for styring af jordforurening og oprensning af forurenede grunde varierer i de nordiske lande. Der anvendes forskellige tilgange til at sætte baggrunds- eller referenceværdier, definere prøvetagnings- og teststrategier samt statistisk behandling af resultater fra prøveudtagning. Imidlertid har de anvendte typer juridiske instrumenter, hvordan identifikation og registrering af jordforurening sker, og hvilke grænseværdier der anvendes, en naturlig indflydelse på, hvordan udgravet jord og andre naturligt forekommende materialer håndteres. Denne juridiske ramme dækker således vurderingen af masser inden udgravning, såsom udgravning af jord, nedbrudt grundfjeld, grus, sand osv. Der er dog forskelle mellem vurdering af forurenede lokaliteter og vurdering af udgravede masser. Derudover er der forskelle mellem brug på stedet og off-site af materialer, især forurenede jord.

Vurdering af lokaliteter initieres gennem de juridiske instrumenter, der er på plads i landene, såsom national lovgivning om jordforurening. Der kan dog være forskelle i, om dette sker som en systematisk og kontinuerlig proces på nationalt eller lokalt grundlag eller som en case-by-case og derfor stedsspecifik risikovurdering. Dette har indflydelse på, om der er viden om mulig forurening før udgravning af jord eller andre naturligt forekommende materialer. Som beskrevet er der også forskelle i de miljøkvalitetsstandarder eller grænseværdier, der anvendes i risikovurderingen af jordforurening.

Hvilke skridt skal interessenter tage, når materialer skal udgraves og bruges enten på stedet eller off-site? Der er forskellige tilgange for stenmasser sammenlignet med andre udgravede materialer. Stenmateriale betragtes generelt ikke som en kilde eller et magasin for farlige stoffer fra forureningsaktiviteter. På grund af dette udtages og testes der normalt ikke stenmateriale uden finkornede partikler for at bestemme forureningsindholdet før udgravningsaktiviteter, bortset fra naturligt forekommende stoffer, der kan udgøre en risiko for skadelige virkninger ved udgravning, eller rester fra sprængstoffer. Andre udgravede materialer, såsom jord, prøvetages, testes og vurderes typisk i forhold til miljøkvalitetsstandarder. Dette kan være standarder defineret i lovgivning i form af grænseværdier, men kan også være tærskel- og vejledningsværdier som en del af risikovurderingen. Dette varierer i de nordiske lande.

Flere fælles lovgivningsmæssige såvel som praktiske udfordringer skal løses for at

muliggøre en mere ressourceeffektiv håndtering af naturligt forekommende materialer.

Eksisterende lovgivning er ikke en direkte barriere, der forhindrer optimal udnyttelse af ressourcerne. Der er dog flere uudnyttede muligheder i regulering såvel som problemområder, der fremstår som barrierer i praksis. Disse problemområder er for eksempel mangel på specifikke krav, komplekse regelsæt, klassificering af affald, krav til affaldsstatistik.

Effektiv udnyttelse af naturligt forekommende materialer i de nordiske lande står over for en lang række udfordringer i praksis og fra forskellige vinkler. Det er samspillet mellem forskellige faktorer, der repræsenterer udfordringer eller faktiske barrierer for effektiv håndtering af naturligt forekommende materialer, fx for entreprenører. Dette inkluderer aspekter som planlægning, indledende undersøgelser, manglende krav i regulering og / eller udbudsdokumenter, manglende information og koordinering, klassificering som affald / ikke-affald, håndtering i henhold til forureningsniveau og omkostninger.

Baseret på viden eller barrierer og udfordringer blev der formuleret anbefalinger til myndigheder og operatører i projektet. Anbefalinger til myndigheder fokuserer på politiske instrumenter og vejledning, der kan være fremmende for effektiv håndtering af naturligt forekommende materialer, såsom henholdsvis behovet for at udvikle nye fremtidige gældende instrumenter eller behovet for at tilpasse eksisterende politiske instrumenter. Anbefalinger til operatører fokuserer på bedste praksis identificeret i relevante studier på nordisk niveau og vejledning til relevant og passende brug af materialer.

Summary

Naturally occurring materials represent a high resource potential – if used more efficiently. Optimized handling of the materials, however, presupposes that we have knowledge of the materials, possible level of pollution, regulation in the area and knowledge of potential barriers and challenges in managing the materials.

Several different kinds of materials are covered by the term "naturally occurring materials". Excavation of these materials in building and construction can be done in different ways and using different kind of equipment, generating materials that are differing in quality and characteristics. Infrastructure projects in Norway and Sweden, where the geology is dominated by rocks require different approaches and equipment as compared to projects, where materials consist of a mix of soil, decomposed bedrock, clay, silt, sand, gravel etc. that can be excavated with an excavator. The quality of the materials that are generated by the different methods varies in terms of particle size, composition, and contamination levels. Consequently, it is important to be able to distinguish between them when collecting information about quantities as well as regulation, best practice, and challenges in the management of the materials.

The management of naturally occurring materials in the Nordic countries is regulated by a complex set of legislation which is based on, but not exclusive, environmental legislation, waste legislation, soil legislation, land use and building regulations. The management of materials requires either notification to authorities or permits. Although specific legislation on soil exists in all countries, there is no single, specific legislation for the management of rock masses from either drill and blast activities or TBM.

In all Nordic countries underlying sets of guidance documents and handbooks exist, however, to varying degree. Work is ongoing regarding development and update of guidelines etc. E.g. in Sweden guidelines, handbooks and other legal documents from agencies regarding handling of masses, by-products and waste are being updated, including the Swedish Building Act which is under revision. In Norway and Finland new legislation is on the way that has focus on the management of excess unpolluted materials generated in construction activities and the management of uncontaminated soils, respectively.

Due to geographical differences between the Nordic countries, there are natural differences with respect to the types and amounts of materials, that need to be managed in the Nordic countries. The mapping of relevant materials showed, that excavated materials such as a mix of soil and other mineral masses is the most dominating fraction in Denmark and Finland, whereas rock masses from drilling and blasting activities as well as tunnel boring machines constitute significant quantities in Norway and Sweden. There are substantial differences in the amount of naturally occurring materials that are managed on an annual basis.

Based on the gathered information it can be said that there is a potential for optimized management of naturally occurring materials in the Nordic countries. However, based on the available data and information it is not possible to give a quantitative estimate on how large this potential is. This is due to the fact that national waste statistics are a poor tool to provide a detailed overview of amounts of materials and their management in practice and do not reflect the different types

of materials nor their respective geotechnical properties. Another reason is that materials, that are used on-site of excavation areas typically are not registered at all. Consequently, it is difficult to get a good overview of important material streams, how they are managed and how large the potential for optimized management is.

The classification of naturally occurring materials as waste or non-waste/resource is of great importance for the management of the materials. Classification as waste does not mean that the materials must not or cannot be utilized, they may still be recovered or recycled. However, classified as waste means that materials are subject to the waste legislation and the consequences that this entails for approvals, permits, compliance with relevant limit values, fees and taxes etc. This has a great influence in practice on the timeframe for decisions such as permits or approvals, which in turn has a strong impact on costs and consequently choices and possibilities for material management. This presupposes that the contractors have sufficient knowledge and expertise to be able to assess whether a material is waste or not in each situation to be able to apply for permits or whatever may be relevant.

The legal framework for management of soil contamination and remediation of contaminated sites varies across the Nordic countries. Different approaches to setting background or reference values, defining sampling and testing strategies as well as statistical treatment of results from sampling are used. However, the types of legal instruments applied, how the identification and registration of soil contamination is done, and which limit values are applied have a natural influence on how excavated soil and other naturally occurring materials are managed. This legal framework thus covers the assessment of masses prior to excavation, such as excavation of soil, decomposed bedrock, gravel, sand etc. However, there are distinctions between assessment of contaminated sites and assessment of excavated masses. Moreover, there are distinctions between on-site and off-site use of materials, especially contaminated soil.

Assessment of sites is initiated through the legal instruments that are in place in the Nordic countries, such as national act on soil contamination. However, there may be differences in whether this is done as a systematic and continuous process on national or local basis or as a case-by-case and therefore site-specific risk assessment. This has influence on whether there is knowledge of possible contamination prior to excavation of soil or other naturally occurring materials. As described, there are also differences in the environmental quality standards or limit values used in risk assessment of soil pollution.

Which steps need to be taken by stakeholders when materials are to be excavated and used either on-site or off-site? There are different approaches for rock masses as compared to other excavated materials. Rock material in general is not considered a source or a sink for hazardous substances from pollution activities. Because of that, rock material without fine grained particles is usually not sampled and tested to determine content of pollution prior to excavation activities. This except for naturally occurring substances that might pose a risk of harmful effects when excavated or residues from explosives agents used in drill and blast excavation. Other excavated materials, such as soil, is typically sampled, tested, and evaluated against environmental quality standards. This can be standards defined in legislation in form of limit values but can also be in terms of threshold or guidance values as part of risk assessment. This varies in the Nordic countries.

Several common regulatory as well as practical challenges must be solved to enable a more resource efficient management of naturally occurring materials.

Existing legislation is not a direct barrier that prevents optimal utilization of resources. However, there are several untapped opportunities in regulation as well as problem areas that appear as barriers in practice. These problem areas are for instance, lack of specific requirements, complex set of rules, classification of waste, requirements for waste statistics.

Efficient utilization of naturally occurring materials in the Nordic countries faces a wide range of challenges in practice and from different angles. It is the interplay of different factors that represents challenges or actual barriers for the efficient management of naturally occurring materials, e.g., for contractors. This includes aspects such as planning, preliminary investigations, lack of requirements in regulation and/or tender documents, lack of information and coordination, classification as waste/non-waste, management according to pollution level and costs.

Based on the knowledge of barriers and challenges, recommendations for authorities and operators were formulated in the project. Recommendations for authorities focus on policy instruments and guidance that may be beneficial for the efficient management of naturally occurring materials, such as the need to develop new future applicable instruments, or the need to adapt existing policy instruments, respectively. Recommendations for operators focus on best practice identified in relevant studies at Nordic level and guidance for the relevant and suitable use of materials.

1. Introduction

1.1. Background

There is a shared interest and aim in the Nordic countries towards a more circular economy. However, very little attention is given to the large amounts of naturally occurring materials, that need to be managed annually because of excavation activities in construction, remediation and building projects – generating large amounts of excavated soil and rock as well as other naturally occurring materials of different origin.

Due to geographical differences between the Nordic countries, there are natural differences with respect to the types of materials, that need to be managed. In Denmark, soil is the predominant waste fraction, whereas excavated rock is a relevant type of material in Norway and Sweden. In Finland, surplus soil masses comprising partly slightly contaminated and partly clayey soils generated from the fast-growing land development areas are predominant materials.

Furthermore, to use these materials in a more efficient and optimized way following the principles of a circular economy, a change in waste legislation, standard requirements for documentation, policies and regulation is needed.

Naturally occurring materials are not necessarily free from problematic substances. They might contain natural pollution or anthropogenic pollution. The occurrence of pollutants may hamper the efficient utilisation of excavated naturally occurring materials, since the presence of problematic substances may represent a risk for the environment. What to prioritize? The efficient use of resources or the protection of the environment from pollution by harmful substances?

The efficient management of large amounts of soil, rock and other naturally occurring materials in practise sets high requirements for sufficient storage capacity, logistics, time to handle the materials in an efficient way and communication between stakeholders.

For stakeholders there is a need to have access to tools and guidance for the estimation of masses, volume, and risk assessment, which currently is lacking. Moreover, this puts focus on a high level of traceability of the materials and chain of custody to secure, that materials have the quality needed for an indented application.

To provide a basis for developing future applicable instruments there is also a need to have an overview of the amounts of materials managed and their potential for optimised handling. It would be natural to assume that naturally occurring masses are included in the concept of "construction and demolition waste", but as we will show later in the report, this is not always true.

Waste generated in the construction sector in the Nordic countries represents a large share of the total annual waste generation, as the figures in Table 1 illustrate. Figures on the waste generation and information on management of construction and demolition waste (C&D waste) are accessible via waste statistics and reports/studies and often include information on different types of C&D waste, such as concrete, asphalt, metals, wood waste. However, to what extent is information available on the amounts and management of naturally occurring materials?

Table 1 Total waste generation in 2018 in the Nordic countries (Denmark (Danish EPA, 2020), Finland, Sweden, Norway) as compared to waste generated in the construction sector alone in the Nordic countries (Eurostat, 2021 a, b, c).

2018 Mio tonnes	Total waste generation incl. mining waste	Total waste excl. mining waste	Generation of waste in the construction sector	Construction waste pr capita (t/ person)	Percentage of total waste generation (%)
Denmark		12.4	5.1	0.9	41
Finland	128.3	32.2	15.7	2.8	12
Sweden	138.7	35.0	12.4	1.2	9
Norway		14.1	5.7	1.1	40

Table 1 also illustrate that waste statistics vary from country to country, and there are differences in what is registered in the countries. When comparing generation of construction waste per capita the waste statistics indicate that approximately the same amount of C&D waste is generated per person in Denmark, Sweden, and Norway. However, the generation of C&D waste in Finland seems three times as high as compared to the other Nordic countries.

Regarding statistics on waste generation there are discrepancies in total waste generated in each country. In data for Finland and Sweden mine tailings are included and represents by far the largest fraction of waste generated with 103.6 Mio tonnes in Sweden as an example. With mine tailings excluded Sweden generated 35 Mio tonnes of waste in 2018.

1.2. Objectives and scope

Naturally occurring materials represent a high resource potential – if used more efficiently. Optimized handling of the materials, however, presupposes that we have knowledge of the materials, possible level of pollution, regulation in the area and knowledge of possible barriers and challenges in managing the materials.

To provide answers to these issues the project will fulfil the following objectives, where greatest emphasis was put on objective 2 and 3:

1. Compile information on types of wastes and materials generated and how those typically are managed in the 4 Nordic countries.
2. Examine and describe policy instruments as well as national strategies that are relevant for the management of soil, rock and other naturally occurring materials.
3. Describe how and to what extend risk assessment is applied in the management of relevant material streams.
4. Describe available best practise and lessons learned and recommend solutions

for the optimised management of relevant waste and material streams to relevant stakeholders.

The scope of this project is defined as described below:

Scope of this project

(Waste) materials, that are excavated during building and construction projects as well as remediation in construction.

The Norwegian EPA fact sheet Guidance on the Pollution Control Act's requirements for intermediate storage and final disposal of soil and rock masses that are not contaminated. (Miljødirektoratet, 2021a) defines "naturally occurring materials" as "natural mineral masses consisting of decomposed bedrock and crushed rock, such as clay, silt, sand, gravel, crushed stone and other stone. In addition, mineral masses containing converted organic material, such as topsoil, bog soil and the like are included".

Mud masses/dredged material, i.e., masses and sediments excavated from ports and lakes in connection with construction activities are included in this study. Polluted soil and naturally contaminated soils, that are excavated during building and construction projects are included. Rock material from tunnel and road construction is included.

This excludes manufactured mineral materials, such as concrete and asphalt, as well as sediments and mud masses from freshwater and seabed. Mixed fractions where soil and rock masses are mixed in, for example construction and demolition waste, such as crushed asphalt and concrete, paint flakes and the like, are also not included. This approach is used to define the scope.

The project will focus on the management of these materials in Denmark, Sweden, Norway, and Finland.

Building and construction project: Meaning the construction of residential, institutional, commercial industrial buildings, infrastructure (such as highways, roads, tunnels, waste management and water management facilities).

Remediation in construction. Meaning the removal of contaminated wastes or hazardous material from the site of a construction project. However, this excludes contaminated or hazardous materials from the building or construction itself.

1.3. Methodology and guidance to the reader

In chapter 2 we have presented previously conducted or on-going projects and initiatives that have focus on naturally occurring materials.

In chapter 3 the reader can find information on the generation of naturally occurring materials in the Nordic countries. This includes information on available statistics and the management of materials.

When gathering and describing relevant national regulations, approaches to risk assessment, guidance documents and strategies, we have placed emphasis on limiting the description to the most central information. Nevertheless, it adds up to a great deal of complex information for the reader. We have chosen to present the more descriptive information on relevant policy instruments and strategies etc. in appendix 2 and highlight the most important differences and similarities in the Nordic countries in chapter 4. Chapter 4 also contains information on how and to what extent risk assessment is applied in the management of relevant material streams.

The management of naturally occurring materials is not free from barriers and challenges. Chapter 5 presents some of the policy instruments that are perceived as barriers as well as some of the challenges that contractors and other stakeholders experience in the management of naturally occurring materials in practise.

In chapter 6 recommendations for authorities and contractors are presented that have potential to improve the management of naturally occurring materials.

1.4. Types of naturally occurring materials

As described under the scope of this project, several different kinds of materials are covered by the scope of this project and the term "naturally occurring materials". Excavation of these materials in building and construction can be done in different ways and using different kind of equipment, generating materials that are differing in quality and characteristics.

Infrastructure projects, such as the construction of roads and especially tunnels require different approaches for removal of naturally occurring materials in Norway and Sweden where the geology is dominated by rocks. Rock masses can be excavated using tunnel boring machines (TBM). Rock masses can also be excavated using drilling and blasting, e.g., blasting a road cut or blasting tunnels.

Intact rock material may contain radioactive isotopes which may represent a barrier to management of materials. Due to the nature of intact rock material, it is generally not considered a sink for other kind of contamination as a result of polluting activities. Adsorption processes will typically not occur, unless in case of rather small particles sizes where large surface areas may enable adsorption of pollutants to a particles surface area. Consequently, rock masses are typically regarded as unpolluted. However, excavation activities, such as drilling and blasting may introduce pollution.

Naturally occurring materials, that consist of a mix of soil, decomposed bedrock, clay, silt, sand, gravel etc. are typically excavated with an excavator. Typically, the topsoil is removed prior to digging up the mix of material, that needs to be removed in the construction process. Depending on where excavation takes place, the materials excavated can be contaminated. On the one hand, excavation activity at formers industrial site may result in slightly polluted or polluted materials. On the other hand, soil is less likely to be contaminated in deep underground construction projects.

The quality of the materials that are produced by the different methods varies in

terms of particle size, composition, and contamination level. Consequently, it is important to be able to distinguish between them when collecting information about quantities as well as regulation, best practise, and challenges in the management of the materials.

Naturally occuring materials



Rock masses, that are excavated by heavy cutting or digging equipment, e.g. tunnel boring machines (TBM).

Photo: Roland zh/Wikimedia Commons



Rock masses, that are excavated by drilling and blasting activities in road or tunnel construction.

Photo: Tom Olliver/flickr



Excavated masses are typically generated with some type of excavator and consist of a mix of soil, mineral masses such as decomposed bedrock, clay, silt, sand, gravel, stones etc.

Photo: Justin Smith/Wikimedia Commons

1.5. European classification of naturally occurring materials

The classification of naturally occurring materials as waste or non-waste is of great importance for the management of the materials. In the boxes below, excerpts from the Waste Framework Directive (WFD) and "Guidelines on the interpretation of key provisions of Directive 2008/98/EC on waste" (EC, 2012) are given.

As can be seen from the boxes below, uncontaminated soil and other naturally occurring materials are excluded from the WFD, if they meet the described requirements. Those requirements are three-fold, meaning that the material must be uncontaminated, excavated during construction activities and certain to be used in its natural state for construction purposes on the same site.

In practice there will be situations where it may be difficult for stakeholders, to assess whether naturally occurring materials fall under the scope of the WFD. As the excerpts from the guidelines on the interpretation of the key provisions of the WFD show, there are examples for how certainty of use could be inferred from and what "on-site use" can be considered. In the later sections of the report, we describe in more detail, how naturally occurring materials are classified in the Nordic countries and what consequences this has for the management of the materials.

Excerpts from the European waste framework directive (Directive 2008/98/EC)

According to the European waste framework directive (Directive 2008/98/EC) *"uncontaminated soil and other naturally occurring material excavated in the course of construction activities where it is certain that the material will be used for the purposes of construction in its natural state on the site from which it was excavated"* is excluded from the scope of the waste directive.

- **"Waste"** means any substance or object which the holder discards or intends or is required to discard.
- **"Construction and demolition waste"** means waste generated by construction and demolition activities.

"All waste streams not explicitly excluded by the WFD are to be classified according to the WFD and LoW (List of Waste)" (Commission notice 2018/C 124/01).

Excerpts from the "Guidelines on the interpretation of key provisions of Directive 2008/98/EC on waste" – not legally binding (EC, 2012)

Section 2.3 Exclusion of excavated soil and other naturally occurring material (article 2(1)(c) WFD)

In order to be excluded from the scope of the WFD, the requirements here are three-fold. The material must be:

- *Uncontaminated*
- *Excavated during construction activities*
- *Certain to be used in its natural state for construction purposes on the same site.*

"The waste management regime applies to any material used on construction that does not cumulatively meet these three criteria. However, it is possible to assess whether such material meets the criteria for by-products and end-of-waste [...], as emphasised by Recital 11 of the WFD."

'Uncontaminated soil' essentially relates to virgin soil or soil that is equivalent to virgin soil [...]. Other naturally occurring material means soil, stones, gravel, rock, etc.

In order to be excluded, the excavated material must be used in a construction activity on the site. Certainty of use could be inferred from, for example:

- *Construction plans or designs for the site in question. These may contain estimates of excavated amounts and whether there will be a surplus or deficit of such material;*
- *Planning-permission conditions;*
- *Construction and demolition waste management plans, if required;*
- *For larger scale developments, the Environmental Impact Assessment (EIA).*

A construction site will usually be defined in relation to the associated planning permission.

Examples of what can be considered to be 'on the site' include:

- *A construction project for a 100 km motorway, where excavated material from one section of construction is used in its natural state in the same construction section.*

Soil or other such material temporarily taken from the site but returned later and used on the site for the purposes of construction (the transport operation as such is not relevant).

Naturally occurring materials, as defined under the scope of this project, and that are regarded as waste, would be covered by chapter 17 – *construction and demolition wastes (including excavated soil from contaminated sites)* in the European list of waste (Commission decision (2014/955/EU)).

Table 2 Naturally occurring materials, covered by chapter 17 in the European list of waste – entry “1705 Soil (including excavated soil from contaminated sites), stones and dredging spoil”; wastes that are considered as hazardous waste are marked with an asterisk (*) in the European list of waste.

Types of waste	Waste codes (hazardous waste)	Waste code (non-hazardous waste)
Soil and stones	17 05 03*	17 05 04
Dredging spoil	17 05 05*	17 05 06
Track ballast	17 05 07*	17 05 08

1.6. Mining wastes

Mining wastes are excluded from the scope of this project. Mining waste originates from excavation processes and the further processing of mineral resources and includes natural mineral masses such as topsoil and waste rock (including rock, gravel, clay, sand etc.) that needs to be removed during extraction of mineral resources, as well as mine tailings, which are a waste fraction from the extraction of minerals.

Although mining waste represents one of the largest waste streams in the EU and contains large quantities of dangerous substances, it is excluded from this study. It is not covered by the scope of this project. Furthermore, the management of mining waste and implementation of related EU-legislation receives much focus and is subject to several publications. More information can be found on the EU-Commissions homepage (Mining waste (europa.eu)) on mining waste.

To ensure proper management of mining waste, especially mine tailings, comprehensive legislation has been put in place at EU-level, comprising the Extractive Waste Directive and implementing measures.

2. Review of previously conducted studies

As a starting point for the project, a list of relevant studies done at the Nordic level has been compiled. The aim was to identify previously conducted Nordic studies or ongoing studies with the same or similar scope to this project, and that might provide relevant waste statistics, description of material management, policy instruments and best practise recommendations. This work was carried out as a desktop literature review.

Similar projects have not been implemented for the Nordic countries before. It has only been possible to find Nordic projects with a focus on circular economy¹ and construction waste. In contrast, it was possible to identify national projects and country studies that relate to the scope of the project. Those are presented country by country in Table 3 with information on the status (ongoing/finished), reference, and a short description. However, these are examples, and the list is therefore not exhaustive. To the extent that the studies and initiatives are completed, and the results are available, they are incorporated into the report. As some projects and initiatives are still underway, they will in the long run come up with results that may be relevant in relation to the scope of the present study. However, due to the schedule of this project, it will not be possible for us to include the results in this present study.

Table 3 List of relevant studies at Nordic level.

Title, status and reference	Short description and keywords
"Helhedsorienteret bæredygtig jordhåndtering" (Denmark) (2014-2016) Reference: Jordhåndtering Forside (xn--jordhndtering-tf.b.dk)	The project addressed among other things the potential economical savings of on-site/local utilisation of excavated soil. The results of the project and its 9 sub-projects are compiled and made available from the project homepage, containing planning and decision-making tools, guidelines, paradigms, tools, etc. More information is included e.g., in appendix 2.
"Bæredygtig jordhåndtering" (Denmark) (2018 -) Reference: Redskaber til mere bæredygtig jordhåndtering - Region Midtjylland (rm.dk)	In 2018 another project followed suit – Region Midtjylland initiated a project on sustainable soil management that resulted in four tools to enable a more sustainable management of soil in practise. More information is included e.g., in appendix 2.
Råstoffer – Er der behov for en national strategi? (Denmark) (2017) Reference: https://www.regioner.dk/media/5365/copenhageneconomics_raastofferer-der-behov-for-en-national-strategi_2017.pdf	There is a growing demand for raw materials from the construction industry. At the same time, the resources we have are coming under increasing pressure. Therefore, Danish Regions has asked Copenhagen Economics to prepare an analysis of the raw materials market in Denmark.

1. Pre-study: Indicators on circular economy in the Nordic countries Nordic cooperation (norden.org), Circular economy in the Nordic construction sector Nordic cooperation (norden.org), Policy Brief - Recycling in the Circular Economy Nordic cooperation (norden.org), Construction and demolitions waste: challenges and opportunities in a circular economy.

Mangler vi råstoffer til fremtidens byggematerialer? (Denmark) (2019-2020) Reference: https://www.teknologisk.dk/mangler-vi-raastoffer-til-fremtidens-byggematerialer/42172	How much sand, gravel and clay do we need when we build our buildings? And where are we going to get it from? Is it really that hard to extract sand and gravel when we live in a country built on just that? And should we not get better at recycling our construction waste? The publication focuses on the many nuances to these questions because there is no single answer.
"Bedre håndtering av jord- og steinmasser" – Prosjekt for bedre håndtering av jord- og steinmasser som ikke er forurenset (Norway) (ongoing) Reference: Miljødirektoratet, Norway (https://www.miljodirektoratet.no/naringsliv/avfall/massehandtering/bedre-handtering-av-jord-og-steinmasser/)	In 2020/21, a cross-sectoral project will be implemented that looks at possible measures and instruments to achieve better management of non-contaminated surplus masses of soil and rock. 11 directorates and agencies have been commissioned by their ministries to contribute to the project within their fields. The aim of the project is to ensure sound and more resource-efficient handling of soil and rock masses that safeguard environmental, climate and area considerations. The project will emphasize measures and instruments that the government can influence, either as responsible for laws and regulations, or as a commissioner of infrastructure projects that generate large amounts of surplus mass. The project will not address contaminated soil and rock masses or other waste fractions. As the project only ends in September, it will not be possible to share results with the present study.
Several plans in Norway for the management of relevant materials on regional and local level, incl. reports for the local authorities (Norway) Guidelines for planning authorities in the municipalities. (Status – see to the right) Reference: Please see to the right.	Plans in Norway for the management of relevant materials on regional and local levels, incl. reports for the local authorities, as well as guidelines for planning authorities in the municipalities. The aim is to enhance re-use and recycling of natural mineral masses and more. Relevant legislation, guidelines and case studies are presented. Barriers and challenges are identified. Regional plan for management of masses in Jaren 2018–2040 (2017) https://www.rogfk.no/f/p1/i7f073407-f074-404a-9502-0e712566b33f/regionalplan-for-massehandtering-pa-jaren-2018-2040.pdf Regional plan for management of masses in Akershus/Viken county (2016) regional-plan-for-masseforvaltning-i-akershus.pdf (viken.no) Management of masses, Vestby municipality (2018) https://www.vestby.kommune.no/kommuneplan.530537.no.html Oestfold county plan – Oestfold towards 2050 (2018) fylkesplan-for-ostfold-mot-2050.pdf (viken.no) Management of masses in Fredrikstad municipality (2019) www.fredrikstad.kommune.no Trondheim municipality fact sheet no. 63 – Management of polluted soil https://www.trondheime.kommune.no/org/naring-samferdsel-klima-og-miljo/miljoenheten/faktaark-om-natur-miljo-og-helse/
Norsk Landbruksraadgivning/NIBIO - Jordmasser - fra problem til ressurs (Norway) (2018) Reference: https://vest.nlr.no/publikasjoner/teamahefte	Guidelines for local management of soil, especially organic material for agriculture in Norway.
SINTEF – Kortreist stein (Norway) (2016–2019) Reference: https://www.sintef.no/projectweb/kortreist-stein/	Project to enhance sustainable management of stone from infrastructure projects in Norway. Several publications (some in English, but all have an English summary) regarding new technologies, business models, guidelines for planning processes etc. identifies barriers.
GeoreCIRC R&D program (Norway) (2017–2019) Reference: https://www.ngi.no/eng/Projects/GEORECIRC	R&D program which focus on efforts on increasing reuse of materials from building and construction projects in Norway. Three main work packages that identify materials, possible reuse applications and the barriers to reuse, geochemical and geotechnical properties of waste materials, development of tools, methods, and a BAT manual to increase reuse of low-level polluted materials.

EarthresQue (Norway) (2020 – on going) Reference: https://www.nmbu.no/tjenester/sentre/earthresque	A Centre for Research-based Innovation funded by the Research Council of Norway. The centre will develop technologies and systems for sustainable handling and treatment of waste and surplus masses. As the project started in 2020, it will not be possible to share results with the present study.
Delegation for a circular economy (Sweden) (2018 -) Reference: Expert group circular construction industry, http://www.delegationcirkularekonomi.se/om-oss/expertgrupper	In 2018, the Swedish government decided to establish a delegation for circular economy. The delegation supports the work of converting the whole of Sweden to a circular economy. One of the expert groups within the delegation is to achieve a circular construction industry. The expert group assignment is to: - propose concrete proposals for changes in guidance, regulations, legislation, and other instruments that in 1–3 years can create more sustainable material flows for building materials in the land and construction industry. - Identify, assess, and prioritize the changes in guidance, regulations, legislation, and instruments that provide the greatest potential societal benefits in terms of economy, climate, environmental protection, and resource management.
A more circular handling of soil and excavated masses, construction rocks and other naturally occurring materials (Sweden) (2021 -) Reference: https://www.naturvardsverket.se/upload/miljoarbete-i-samhallet/miljoarbete-i-sverige/regeringensuppdrag/2021/uppdrag-utredning-schaktmassor.pdf	The Swedish Environmental Protection Agency is commissioned by the Swedish government to investigate the handling of soil and excavated masses, construction rocks and other naturally occurring materials that can be used for construction purposes. The Swedish government wants to make it easier for serious actors to handle excavated masses in a resource-efficient way and promote a transition to a non-toxic circular economy. The Swedish Environmental Protection Agency will report the assignment by 1 June 2022.
Report 1.1 from the Expert Group for Circular construction Industry (Sweden) Reference: https://www.delegationcirkularekonomi.se/download/18.79179b21176dc0a6fcb10579/1610707402737/Expertgruppen%20f%C3%B6r%20Cirkul%C3%A4r%20Anl%C3%A4ggningsindustri(tillg%C3%A4nglig)2.pdf	In the report, the expert group has identified 9 different institutional obstacles and 9 policy instruments and solutions that can both contribute to Sweden's environmental goals, save societal costs, and create circular material flows.
Report from the Delegation of a circular economy- Proposals for policy instruments that can speed up the transition to a circular economy (Sweden 2021) Reference: https://delegationcirkularekonomi.se/download/18.544e1c0b1784a907392da50e/1618560001862/210414%20Delegationens%20rapport%20(tillg%C3%A4nglig).pdf	The Delegation of a circular economy has based on the findings from different expert groups within the delegation, proposed a number of policy instruments to promote the transition to a circular economy.
CircVol 6Aika (Finland) (2018–2020) Reference: https://circvol.fi/	The aim of the CircVol project was to promote the reuse of high-volume side streams and landmasses and to establish a national network of actors in the field, consisting of companies, universities, and the public sector. During the project, operational models were developed to the cities of Helsinki, Turku, Tampere and Oulu to promote the circular economy. In addition, 6 pilot experiments in an urban environment aimed for companies were implemented. Publications of the project can be found at: https://circvol.fi/#toggle-id-11 Some examples of the publications below: - A study of international practices in the management and utilization of dredged material. A background study for the CircVol project http://hdl.handle.net/10138/320202 - New methods for measuring volumes of land masses https://circvol.fi/wp-content/uploads/2020/03/Maamassojen-tilavuuksien-mittaamiseen-uusia.pdf - Acid sulphate soils in circular economy projects: Case Välimaa and Matalahti https://6aika.fi/wp-content/uploads/2020/12/49_2020.pdf

Utilization and disposal of surplus soils in the largest cities (Finland) (2013) Reference: https://ygoforum.fi/wp-content/uploads/2020/03/Ylijaamamaiden_hyotykaytto_loppusijointus_diplomityo_Maiju_Koivuniemi.pdf	A master's thesis in which utilisation and disposal practices of surplus soils in the largest cities in Finland was studied, aiming to improve the conditions for utilization. In addition, the challenges as well as possible solutions were discussed.
New material technology for infrastructure construction "UUMA programme" (Finland) (2006–2010) Reference: https://julkaisut.valtioneuvosto.fi/handle/10138/41387	In order to develop and increase the use of recycled materials, the Ministry of Environment in co-operation with the Ministry of Transport, Tekes, and Sitra launched a development programme called "New material technology for infrastructure construction (UUMA programme)". The objective of the programme was to reduce the use of natural resources and the waste generation in construction. This means reducing the use of gravel resources, and thereby groundwaters and eskers can be saved. New material technology for infrastructure construction refers to a technology that utilizes low-quality surplus masses and aggregates, industrial side products, contaminated soils, and old earthworks. UUMA Programme consisted of eight different projects (Härmä et al. 2010). Two of them are shortly described below: Construction and aggregates - products from surplus (RAKI project). The current situation of the utilization of surplus rocks, and the promotion of their productization and use to replace the use of primary rock resources were investigated in RAKI project. The main goal was to create operations models for enhanced utilization of surplus rocks generated in construction. As an important part for this, the criteria for rock terminals were clarified. In addition, the barriers for better utilization as well as technical, geological, and societal provisions to promote their use were examined. Based on the work, recommendations for further actions were given. These were divided into recommendations for administrative and legislative measures, recommendations for regional planning, and the last one focuses on the functions of individual surplus rock treatment sites (Härmä et al. 2010). Utilisation of low-quality aggregate in infra networks (HUUMA project). The objective of the project was to investigate and promote the utilisation of low-quality materials as materials replacing higher-quality materials. Via utilization the need to stack materials as well as the amount of materials that need to be transported can be reduced. The utilisation of materials onsite also reduces costs and lowers the environmental impacts caused by transportation. The project was focused on the utilization of moraines. During the project, their utilization in the structural layers of roads and streets and in other cases requiring soil filling were investigated (Korkiala-Tanttu et al. 2008).
Development of management of stony materials (Utveckling av hanteringen av stenmaterial) (Finland) (2018) Reference: http://urn.fi/URN:ISBN:978-952-11-4791-3	In the report, a preliminary operations model for management of stony materials is presented. Resource wise aggregate service re-quires well-functioning mass coordination, the removal of barriers for utilisation, and improving the acceptability of aggregate management.

3. Generation of naturally occurring materials and their management

In the following sections information on the generation of naturally occurring materials and their management in the four Nordic countries has been compiled, in order to investigate which materials are used for construction purposes, whether they are used on-site, and what differences in management of unpolluted/virgin materials and slightly polluted materials can be seen.

This was done as a desktop study, based on existing knowledge in this field, knowledge of relevant waste statistics and studies, supplemented with interviews of relevant stakeholders in the sector, such as contractors, waste management facilities, national road administration etc.

As far as possible and depending on the level of information and statistics available, information was compiled with respect to types of materials, amounts, level of pollution, and in what type of activity there are generated.

Furthermore, information on the management of the relevant types of materials was collected, including information on types of materials, amounts, level of pollution, purpose of application, information on transport and costs.

3.1. Denmark

In Denmark, soil is by far the largest waste fraction of relevance to this project and is generated in various types of construction activities. It will typically be generated as a mix of excavated masses, such as a mix of soil and stones and other mineral masses. While part of the data on soil is available via the waste statistics, the remaining part is based on estimates and previously carried out studies. The available data, that is presented in Table 4 is divided as follows:

- Approx. 9 Mio tonnes of soil are registered in the Danish Environmental Protection Agency's (EPA) waste data system (in Danish – AffaldsDataSystem ADS). This includes both unpolluted, slightly polluted (5.62 Mio tonnes) as well as polluted soil (3.519 Mio tonnes) (Danish EPA, 2020).
- In addition to this it was estimated that approx. 6 Mio tonnes of soil notified in accordance with the *Statutory order on notification and documentation in connection with the removal of soil* (Jordflytningsbekendtgørelsen) – i.e., contaminated and expected contaminated soil – are managed in Denmark every year (Jensen, et. al 2017).
- Moreover, there is an unknown amount of soil from land zones that is not notifiable. Land zones include the open country and a large part of the smallest villages (Jensen et. al 2017).

Based on the national statistics and previously carried out studies, a total of at least 15 Mio tonnes of soil are managed every year.

Table 4 Mapping of relevant materials in Denmark (such as soil, rock, sediments, other naturally occurring materials) with respect to types, amounts, level of pollution, and in what type of activity there are generated.

Material types	Amounts Mio tonnes/year	Level of pollution	Type of activity
Soil	3.519 ¹	Polluted	Construction and demolition Soil remediation
Soil	5.620 ¹	Not polluted/slightly polluted	Construction and demolition Soil remediation
Soil	Approx. 6 ²	Not polluted/polluted	Construction and demolition Soil remediation
Soil	Unknown** amounts from land zones	Unknown (but typically unpolluted)	Construction and demolition Soil remediation

¹ Danish EPA, 2020,

² Jensen et. al 2017.

The management of soil is subject to different sets of national regulations (see more in section 4.1 and appendix 2), including the *Statutory order on notification and documentation in connection with the removal of soil* (Jordflytningsbekendtgørelsen), setting out rules for excavation and removal of contaminated or possibly contaminated soil. All excavation and removal of more than 1 m³ soil must be notified to the municipal council, and for the purpose of the notification a special form has been prepared that needs to be filled in. Digital solutions have been developed to facilitate the handling of the notification in practice. Different systems exist, and on the Danish municipalities' website information about which system to use and how to ensure correct notification can be found. There is no requirement for notification of soil from the land zone, and it is not possible to determine from the existing notification systems or the waste data system how much soil is moved from the land zone.

Example of digital solutions

JordWeb (JordWeb): JordWeb facilitates the notification of soil by creating a web-based space for collaboration between the client, municipality, landowner, consultant, contractor, and transportation company. It ensures proper handling of the soil from excavation to landfill. All parties have – with the necessary rights – access to all relevant information on each individual case. Most Danish municipalities use JordWeb.

Each year, a waste statistic is generated by the Danish EPA based on the data which have been collected via the waste data system. All waste collectors, recipients, exporters, and importers of waste are required to report waste data to the system. All reports must contain information on where the waste originates from, and exporters must state who is the recipient of the waste.

For soil, the waste statistics only cover the quantities registered in ADS, i.e., soil that is received as waste. Soil or any other naturally occurring material that is excavated and not handled as waste, will consequently not be part of the waste statistics.

Excavated soil is thus registered in two different systems and the reporting systems operate independently:

- On the one side there is the registration of excavation and removal of soil under the *Statutory order on notification and documentation in connection with the removal of soil* (Jordflytningsbekendtgørelsen). This focusses on soil, that is moved from an area.
- On the other side there is the annual waste statistics, that is compiled from data in the waste data system, where focus is on soil that is considered waste. It is the municipalities that assess when soil is considered waste.

While an annual waste statistic is compiled for the data in ADS, there is no compilation of data from e.g., JordWeb on an annual basis. Moreover, different types of information are registered in the systems. In ADS, for example, EAK code and expected management of soil are to be used. In the other systems, e.g., JordWeb, reports are given stating the level of pollution and general type of soil. The systems are intended to report in terms of pollution level and an expected management as a result of that. The reports are not made based on the technical / geotechnical properties of the materials. Therefore, there is no detailed information on soil type or geotechnical properties of the materials.

The Danish waste statistics provide information on the management of soil on an annual basis. In Table 5 this is shown for 2015–2019. In the statistics unpolluted soil also includes slightly polluted soil. Soil management depends on the different classes of pollution – unpolluted soil, slightly polluted soil and polluted soil (see more information in classification/categorization in appendix 2).



Figure 1 Use of unpolluted and slightly polluted surplus soil in a nature and landscape project near Copenhagen.

Photos: Anke Oberender

"Recovery" includes soil used for e.g., noise barriers, terrain regulation, construction projects, application on agricultural land for the benefit of the environment, land reclamation or similar projects. By "disposal" is meant disposal in landfills. It should be mentioned that this includes excavated soil (both polluted and unpolluted) that is stored temporarily at landfill sites before final recovery. The management of soil, as reported in the waste statistics, is summed up in Table 6.

Table 5 Amounts of excavated soil registered in the waste data system and their management (Danish EPA, 2020).

Polluted Soil	2015		2016		2017		2018		2019	
	Tonnes 1.000	%	Tonnes 1.000	%	Tonnes 1.000	%	Tonnes 1.000	%	Tonnes 1.000	%
Recovery	1329	56	1329	56	1601	65	2053	71	2411	69
Disposal	1043	44	1043	44	866	35	839	29	1108	31
Total	2372	100	2372	100	2467	100	2892	100	3519	100
Un-polluted Soil	2015		2016		2017		2018		2019	
	Tonnes 1.000	%	Tonnes 1.000	%	Tonnes 1.000	%	Tonnes 1.000	%	Tonnes 1.000	%
Recovery	2004	62	2004	62	1870	50	3486	88	5132	91
Disposal	1228	38	1228	38	1878	50	454	12	488	9
Total	3232	100	3232	100	3743	100	3940	100	5620	100
Soil in total	2015		2016		2017		2018		2019	
	Tonnes 1.000	%	Tonnes 1.000	%	Tonnes 1.000	%	Tonnes 1.000	%	Tonnes 1.000	%
Recovery	3333	59	3333	59	3471	56	5539	81	7543	83
Disposal	2271	41	2271	41	2740	44	1293	19	1595	17
Total	5605	100	5605	100	6211	100	6832	100	9139	100

The amount of both contaminated and uncontaminated soil has increased over the past years. It is assumed that this is due to the increased economic activity during the period as well as improved reporting to the waste data system. In the construction industry, soil is traditionally not considered waste in line with other construction and demolition waste. Transport distances play an important role in the management of soil. It is typically too costly to transport excavated soil over larger distances (Danish EPA, 2020). This may result in the disposal of larger amounts of unpolluted soil as compared to polluted soil.

Table 6 Management of soil in Denmark.

Type of material	Amount Mio tonnes/year	Level of pollution	Purpose of application	Information on transport and costs
Soil (2019)	3.519	Polluted	Noise barriers, terrain regulation, construction projects, land reclamation or similar projects.	Long transport distances represent a barrier. Potential cost savings in local utilisation of soil.
Soil (2019)	5.620	Not polluted	Noise barriers, terrain regulation, construction projects, application on agricultural land for the benefit of the environment, land reclamation or similar projects.	Long transport distances represent a barrier. Potential cost savings in local utilisation of soil.

3.1.1. Naturally occurring materials from metro construction in Copenhagen

Civil engineering projects such as the construction of the Metro system in Copenhagen and the construction of the Light Rail system in Greater Copenhagen, Aarhus and Odense, typically generate more excavated soil as compared to the construction of buildings. The construction of the Metro system in Copenhagen uses excavation technologies that are not commonly used in civil engineering projects elsewhere in Denmark. Furthermore, as a result of the applied technologies, excavated materials are generated, that are not typically managed in Denmark. The following information was compiled based on personal communication with the Metro company (Bech, 2021). Among other things, this illustrates, that the level of detail in national waste statistics is very different from project specific details, which we will discuss further in section 4.2.

Table 7 and Table 8 show the quantities of excavated soil and muck from the entire Sydhavnsmetro up to and including November 2020. In addition, it is shown, where soil and muck have been disposed of. The distribution of recipients is primarily controlled by the degree of contamination, so that unpolluted soil is driven to By & Havn, slightly contaminated to KMC (landfill for contaminated soil) and heavily contaminated for cleaning, etc.

Soil – All non-polluted and slightly contaminated soil is used for backfilling in *Nordhavn*. The soil consists of different types, including lime and a mix of other materials. Lime from excavation of station shafts etc. will possibly be used instead of agricultural lime or to produce cement. Transport distances and other practical constraints such as customer structure are expected to pose a significant challenge to exploit this potential.

Table 7 Management of excavated soil from metro construction sites.

Total amount of soil excavated from construction sites distributed on land recipients (period from October 2018 to November 2020)	Tonnes
By & Havn (landfill for unpolluted soil)	372.645
KMC Nordhavn (landfill for contaminated soil)	189.205
Rens, RGS Nordic og Norrecco (cleaning/treatment)	40.972
Kartering ¹ (undocumented soil)	65.020
SUM	667.843

¹ Undocumented soil is soil where the degree of contamination of the soil is not known before excavation. The soil has not been documented with analysis in advance. The mapping includes receiving, handling, analyzing and sorting the soil. Subsequently, the soil will be recovered, disposed of or cleaned depending on what the analyzes show.

Muck – The muck from drilling the tunnels with tunnel boring machine #1 and 2 is used for backfilling in *Nordhavn*. The muck consists mainly of lime with a certain proportion of finely ground flint. In addition, there are small amounts of drilling chemicals, but the ongoing tests show that it is not an environmental problem. The muck may possibly be used instead of agricultural lime or to produce cement. However, the high proportion of flint and impurities in the muck means that the muck is a low-quality product. Transport distances and other practical constraints are expected to pose a significant challenge to exploit this potential. In 2020, muck amounted to approx. 4.700 tonnes, but earlier in the project during the establishment of secant piles, this amount is much larger.

Table 8 Management of excavated muck from metro construction sites.

Total amount of muck excavated from TBM#1 and TBM#2 distributed on land recipients (period from October 2018 to November 2020)	Tonnes
By & Havn	298.505
KMC	38.336
SUM	336.841

3.2. Sweden

Today the amounts of natural occurring materials generated in Sweden are not being followed up on a continuous basis and without any established framework. Actors within the construction sector has estimated that a total of about 60 Mio tonnes of naturally occurring materials are generated in Sweden annually, see Table 9 (Expertgruppen för Cirkulär anläggningsindustri, 2020). The amounts are based on data from a number of sources such as construction companies, consultants, haulage contractors as well as a number of reports published by the Swedish geotechnical institute (Zide, 2021) and comprise excavation masses, soils, and rocks. The dataset does not provide any information of the amounts for different pollution levels. Materials which have been used again on the same site as being generated are not included:

- **Excavated masses** consist of mineral masses such as decomposed bedrock, clay, silt, sand gravel etc. and are mostly unpolluted material but also include contaminated amounts.
- **Soil** generated is unpolluted to the greatest extent, but contaminated soils are also included in the amounts.
- **Rocks** (mechanically excavated materials) generated from tunnel blastings and excess rocks from road constructions consists of mainly non-polluted rocks.
- Information of **dredged spoils** are based on the Swedish waste statistics and cover the year 2018 (Naturvårdsverket, 2020a). It is not possible in the statistics to identify the type of activity generating dredging spoils, but a qualified estimate is that most amounts are generated from work with the aim of removing bottom material to give the water a desirable depth.

The estimated figures of generated amounts are associated with several uncertainties. As a comparison about 6 Mio tonnes of waste consisting of soil and excavation masses are generated in Sweden according to the national waste statistics (Naturvårdsverket, 2020a). The amounts of mineral waste are not included as they to a great extent contain mixed and combustible waste for sorting which is not of interest in this study.

The reason for the large difference between the estimates presented by the expert group for a circular construction sector (Expertgruppen för Cirkulär anläggningsindustri, 2020) and the Swedish waste statistics is that the Swedish waste statistics only include waste received by waste management facilities which are obligated to send in an environmental report and thus being of a certain size and environmental impact (cf. "Miljöbalkens 26 kap. 20 §"). Therefore, received waste amounts at treatment facilities which are not obligated to send in environmental reports such as landfills only having permits of landfilling inert waste or using the waste for construction purposes at the landfill, are not included in the national waste statistics. In a corresponding manner, received secondary materials for construction purposes on construction sites are not included in the national waste statistics.

Table 9 Mapping of naturally occurring materials) with respect to types, amounts, level of pollution, and in what type of activity there are generated. The amounts of dredging spoils are based on Swedish waste statistics (Naturvårdsverket, 2020a) and the amounts of other material types are based on a report by the construction sector (Expertgruppen för Cirkulär anläggningsindustri, 2020). The level of pollution and type of activity are based on estimations by the authors of this report.

Material types	Amounts Mio tonnes/ year	Level of pollution	Type of activity
Excavated masses	35	Mostly non-hazardous waste but also hazardous waste	Construction and demolition Soil remediation (Civil engineering, demolition and site preparation)
Soils	12	Mostly non-hazardous waste but also hazardous waste	Construction and demolition Soil remediation (Civil engineering, demolition and site preparation)
Rock (mechanically excavated material)	10	Mostly non-hazardous waste	Construction purposes (e.g. tunnel blastings, road constructions)
Dredging spoils (non-hazardous)	0.365	Non-hazardous waste	Construction and maintenance of water project, dredging and subsurface work
Dredging spoils (hazardous)	0.0198	Hazardous waste (containing heavy metals and/or organic pollutants)	Construction and maintenance of water project, dredging and subsurface work
Total	58		

Table 10 shows how the generated amounts are managed. For excavated masses and soils, the management (purpose of application) are based on the Swedish waste statistics (Naturvårdsverket, 2020a), which do not distinguish between the two waste streams why they have been merged in the table below. Furthermore, the waste statistics only include masses received by waste management facilities which are obligated to send in an environmental report as mentioned above. This explains the major difference between generated and received amounts for excavated masses and soils presented in the table below. Mechanically excavated materials generated from tunnel blastings etc. consists mainly of rocks which are not polluted and are to the greatest extent crushed and used for construction purposes (Zide, personal communication, 2021). Regarding managed amounts of dredged spoils, they are also based on the Swedish waste statistics and are disposed at sea to the greatest extent, but considerable amounts are also being landfilled (Naturvårdsverket, 2020a). Information about transports and related costs are based on underlying documents (see Expertgruppen för Cirkulär anläggningsindustri, 2020a) in the report from the expert group *circular construction industry* in the Swedish delegation for a circular economy (Expertgruppen för Cirkulär anläggningsindustri, 2020).

"Backfilling" means a "recovery operation where suitable waste is used for

reclamation purposes in excavated areas or for engineering purposes in landscaping and where the waste is a substitute for non-waste materials" (Directive 2008/98/EC). Based on the definition in the Directive, Eurostat (2021) has given guidance to how backfilling should be interpreted.

Table 10 Management of naturally occurring materials in Sweden (Naturvårdsverket, 2020a), (Expertgruppen för Cirkulär anläggningsindustri, 2020). The level of pollution and type of activity are based on estimations by the authors of this report.

Type of material	Amount Mio tonnes/ year	Level of pollution	Purpose of application	Information on transport and costs
Excavated masses and soils	47.5	Mostly non-hazardous waste but also hazardous waste	Landfilling: 2.413 Mio tonnes of which 0.313 Mio tonnes is hazardous waste Backfilling: 0.832 Mio tonnes Construction purposes (mostly on landfills): 3.155 Mio tonnes of which 0.155 Mio tonnes is hazardous waste	About 50 km to landfill on average Cost of transport: 3 SEK/ton km
Mechanically excavated material	10	Mostly non-hazardous waste	Crushed and used for construction purposes: 10 Mio tonnes	About 100 km to landfill on average 3 SEK/ton km
Dredging spoils (non-hazardous)	0.365	Non-hazardous waste	Disposed at sea: 0.230 Mio tonnes Landfilling: 0.107 Mio tonnes Backfilling: 0.027 Mio tonnes	No data available
Dredging spoils (hazardous)	0.0198	Hazardous waste (containing heavy metals and/or organic pollutants)	Landfilling: 0.0198 Mio tonnes	No data available

3.3. Norway

In Norway, the largest fractions of relevance for this project are excavated masses from all kinds of building activities consisting of mineral masses such as soil, decomposed bedrock, clay, silt, sand, gravel - both unpolluted and polluted materials - and mechanically excavated materials from tunnel projects, that mainly consist of rock.

There is no official statistic on the amounts of natural mineral masses that are not polluted. This is a consequence of the legislation, which only demands reports of polluted materials. Material types are in general defined as unpolluted or polluted materials, according to the definition of polluted soil and limit values in the regulations for polluted soil (further described in chapter 9.3). Furthermore, the relevant material types in Norway are listed in Table 11. The material types are based on:

- the material types in the Norwegian EPA Guidance on the Pollution Control Act's requirements for intermediate storage and final disposal of soil and rock masses that are not contaminated (Miljødirektoratet, 2021a)
- available official waste statistics
- relevant studies (mostly numbers from authorities' plans for management of naturally occurring materials (see references in chapter 2)
- experience from own work, and
- feedback from the industry and R&D network (see references in chapter 2).

Lime cement stabilised clay is included in Table 11 to show that the material type is relevant for Norway, but there is no statistics of the management of this material type. The material type is generated during excavation of unstable clay, where clay is stabilized using lime and/or cement to make excavation possible. In our experience, this material is typically landfilled or disposed as unpolluted soil or clay in Norway.

Table 11 Mapping of relevant materials in Norway (such as soil, rock, sediments, other naturally occurring materials) with respect to types, amounts, level of pollution, and in what type of activity there are generated.

Material types	Amounts Mio tonnes/year	Level of pollution	Type of activity
Excavated masses, such as decomposed bedrock, crushed rock, clay, silt, sand, gravel, crushed stone, other stone	26 ¹	Unpolluted	Construction, demolition, soil remediation
Mechanically excavated material (incl. TBM masses)	19 ² 11–21 ³	Unpolluted or polluted (mainly unpolluted rock)	Construction, especially tunnels
Lime cement stabilized clay	No official statistics	Unpolluted or chemical polluted (in addition to the added lime and/or cement)	Construction, demolition, and soil remediation in areas with unstable clay
Polluted soil, including acid-forming shale and other polluted rock	2.153 ⁴	Pollution class 2–5 (see definition in appendix 2)	Construction, demolition, soil remediation
Mineral masses containing converted organic material, such as Topsoil Bogsoil	No official statistics	Mainly unpolluted (can be polluted)	
Dredging spoils	No official statistics	Unpolluted or contaminated	Construction and maintenance of water project, dredging and subsurface work

¹ Calculation by Eirik Wærner in 1996, based on figures for surplus excavated masses in one road- and railway project (Fellesprosjektet Vestby). Specific figures per square meter road/railway was calculated, and this was scaled to national level. Results are uncertain because the base figures rely on one project only.

² Source: Rise et al (2019).

³ See Table 12 (<https://nff.no/publikasjoner/tall-og-statistikk/>).

⁴ Average annual exca-vated polluted soil 2012–2019 (Statistics Norway, www.ssb.no).

In general, mechanically excavated material masses and stone are in general considered clean and in general more likely to satisfy technical requirements for re-use (with and without further processing), but these masses might be polluted with small plastic tubing from rock blasting and residues of nitrogen compounds from dynamite. Rock/stone appears to be more attractive to entrepreneurs for re-use than the other materials listed in C&D projects.



Figure 2 Preparation for drilling and blasting during tunnel construction project on the new E18 highway from Sandvika to Hønefoss at Sollihøgda.

Photo: Eirik Wærner

In order to give an idea about the volumes and distribution between different types of projects, data from The Norwegian Tunnelling Society (NFF) statistics of masses from tunnel projects are presented in Table 12 and Figure 3.

Table 12 Amount (Mio tonnes) of rock from tunnels in Norway from 2016–2020 (NFF, 2020 (recalculated from m^3 to tonnes by the authors)).

	2020	2019	2018	2017	2016
Railway	2.1	0.4	3.2	5.,0	2.2
Highway	5.4	4.2	7.7	10.6	13.5
Underground/ Metro	2.6	0.4	0.0	0.0	0.0
Water supply	0.1	0.3	0.6	0.0	0.0
Hydropower	2.0	4.0	3.5	2.1	2.2
Sewage	0.0	0.0	0.0	0.8	1.0
Storage caverns	0.5	4.4	4.6	2.0	0.6
Others	1.2	8.0	3.0	0.3	0.6
SUM	13.9	21.7	22.6	20.8	20.1

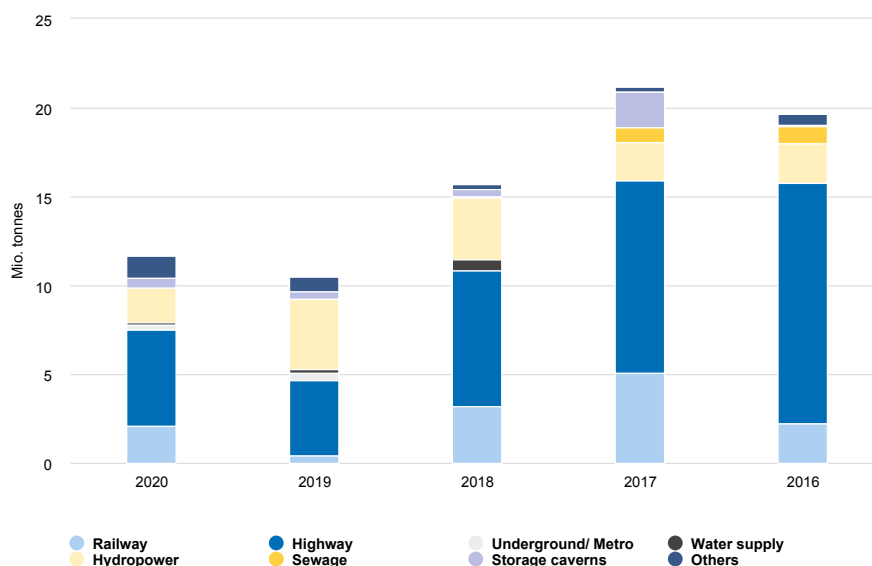


Figure 3 Amounts for rock from mechanically excavated materials from different types of tunnel projects in Norway from 2016–2020 (NFF, 2020).

As there are limited official data available on the management of unpolluted natural mineral materials in Norway, it was not possible to collect information on amounts, purpose of application, transport, and costs on a national level, except for polluted soil in Table 13.

The source in Table 12 give data for the amount of masses typically generated by different kinds of C&D projects from 1971–2020. From 1971, there has been a shift from hydropower to highways as the dominant source of mechanically excavated materials. A forecast of estimated mass types generated from seven large infrastructure projects started and planned in the Oslo region from 2019 to 2030 indicates nearly 60 Mio tonnes of masses (Bærum ressursbank, 2021a).

We have also investigated with Statistics Norway on statistics for the transport of rock and other mineral masses. The figures from Statistics Norway show 11.1 Mio tonnes in 2018, 10.9 Mio tonnes in 2019, and 14.3 Mio tonnes in 2020 (Granerud, 2021). Generated quantities from tunnel activities alone amounted to 15.7, 10.5 and 11.6 Mio tonnes, respectively, which indicates that these statistics do not include all transport, and therefore cannot be used in this project.

A qualified guess of how large quantities of unpolluted excavated masses occur in Norway will be 40–50 tonnes annually. This is based on the estimate made in 1996 – see Table 12 – (which only included national roads and railways). After that time, waste from tunnel projects has increased significantly, and large amounts of excavated masses occur at all house construction projects and all other types of constructions than national roads / railways. When, for example, replacing telephone poles that are anchored in soil, at least one cubic meter of slightly contaminated soil is created.

Table 13 Management of natural mineral masses in Norway.

Type of material	Amount Mio tonnes/year	Level of pollution	Purpose of application	Information on transport and costs
Natural mineral masses, e.g. decomposed bedrock, crushed rock, clay, silt, sand, gravel, crushed stone, other stone	No official data	Unpolluted	Agricultural purposes, landscaping, technical infrastructure such as roads etc. ²	No official data
Mechanically excavated material masses (incl. TBM masses)	No official data	Unpolluted (if not polluted by accidental spills during drilling)	Landscaping, technical infrastructure such as roads etc., additive in concrete structures, agricultural purposes. ²	No official data
Polluted soil	2.758 tonnes in 2019 ¹	Low level, Class 3 or lower (moderate and high level of pollution not included in the amount)	Re-use within C&D projects, including infrastructure projects (typically noise barriers, roads etc.)	No official data
Lime Cement stabilised masses	No official data	Unpolluted with lime and/or cement or contaminated clay including lime and/or cement	No known applications today (transported to landfills)	No official data

¹ Source: Statistics Norway, Waste Accounting year 2019.

² According to Aarstad et al (2019), excavated rock material is utilized to a varying extent for road-, railway- and concrete purposes, but significant amounts are used as deposits on land and in water.

According to the waste accounting of Statistics Norway from 2019, 97% of the total amount of polluted soil was transported to landfills. The total amount of polluted soil handled in 2019 was probably higher than the 2.758 Mio tonnes accounted for in the waste statistics, as the amount does not include the amount re-used on site (which is not included in the end reports for management of polluted soil).

3.3.1. Special projects

There are several projects that would be relevant to present in this chapter. The projects presented in this report is selected based on topicality (projects close in time), size (Follobanen and Fornebubanen), easy access to relevant data for this report and other R&D projects with overlapping results.

Facilities for re-cycling of polluted materials

There are some facilities for re-cycling of polluted materials to clean materials in the Oslo area, Trondheim and Bergen (e.g. AF Decom environmental park, miljopark.no and Velde, velde.no).

Kortreist stein

A summary of relevant experiences from this project is given in chapter 5.

GeoREcirc

The main aim of the GeoREcirc research project is to develop methods that can be used in order to reduce the amount of material that is landfilled and to encourage

reuse. The project will focus on increasing the reuse of excess and waste materials from building and construction projects that are considered to be clean and that have the potential to be reused.

Follobanen

The Follo Line Project is currently the largest infrastructure project in Norway and will include the longest railway tunnel in the Nordic countries. The Follo Line Project is a part of the larger InterCity development in the Oslo region. The project includes a new double track line between Oslo Central Station and the regional town Ski. The new railway consists of a 20 km long twin rail tunnel and will reduce the total travel time from 22 minutes to 11 minutes. The main construction work started in 2015 and will end in 2022.

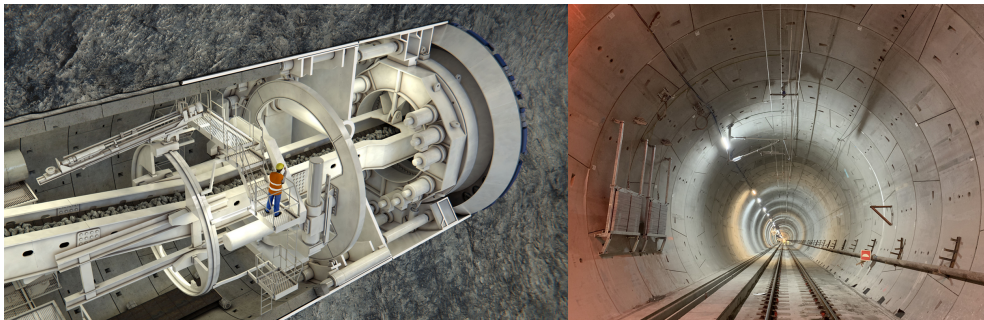


Figure 4 (left) An illustration of the TBM behind the cutterhead.

Illustration: AGJV

(right) Inside one of the tunnels.

Photo: Bane NOR

The project has generated 9.2 Mio tonnes of TBM masses, which have been taken out in the middle of the route. The developer, BaneNOR, called for an early buyer of the masses. Several possibilities were investigated, but it was too complicated to transport the masses from the rig area to the sea. Some of the masses were to be used as aggregates to produce concrete elements in the tunnel, but this had to be shelved, as too high concentrations of pyrrhotite were found, which would lower the concrete quality to an unacceptable level. Most of the masses have been used to fill up an area south of Oslo that will be developed into a residential area (Kalager, 2021).

Fornebubanen, underground railway in Oslo area

The 8 km underground railway project Fornebubanen from Oslo to Fornebu is estimated to generate 2.100.000 m³ stone (mechanically excavated materials) and 500.000 m³ soil (excavated materials) alone (Fornebubanen, 2021). It is stated on Oslo municipality's web page that the surplus materials are suitable for backfilling, but not for building roads or in concrete.

The project was granted funding from the Government for several projects to minimize the environmental impact (including CO₂ emissions) during the

construction phase. One of the projects aim is to reduce the emissions from management of excavated materials by assessment of how to re-use as much as possible and how to reduce the transport distances.

It is also established a local facility to re-cycle and re-use materials from the project (Fornebubanen, 2021).

Baerum Resource Bank

Baerum Resource bank (Bærum Ressursbank, 2021a) is a project in co-operation of authorities (national, regional, and local), entrepreneurs, landowners, developers, scientists which aims to enhance re-use, re-cycling and utilization of surplus materials from C&D activities in the region. The project is funded by the Norwegian EPA and Baerum municipality in addition to R&D funding from Regional Research Fund Viken and Enova.

The project has estimated the amounts (m³) of different types of materials expected from several large infrastructure projects planned in and around the capital of Norway. The projects include:

- New water supply tunnel from Holsfjorden to Oslo, Baerum and Asker municipalities
- New rock cavity for water treatment plant in Oslo
- New underground railway from Majorstuen to Fornebu (Fornebubanen)
- New E18 highway from Lysaker to Ramstadsletta
- New E18 highway from Sandvika to Hønefoss
- New railway line and tunnel from Sandvika to Hønefoss
- New water treatment plant in Asker/Baerum



Figure 5 Excavation for the new E18 highway from Sandvika to Hønefoss at Sollihøgda.

Photo: Eirik Wærner

These projects generate large volumes of masses, which are in addition to masses from other building and construction activities in the area. During the period 2020 to 2030 it is estimated that 21 Mio m³ (or 58 Mio tonnes) of masses will be generated (Bærum ressursbank, 2021a).

The Resource Bank gathers different stakeholders and exchange experiences and solve challenges together. According to the project website, several of the stakeholders have implemented and carried out measures to improve the management of excavated materials in their projects towards the circular economy mindset (Bærum ressursbank, 2021b). The project is currently working to establish a marketplace for the purchase and sale of surplus materials, so that much of the coordination work, that currently is done by Baerum Resource Bank, eventually can be left to the market.

3.4. Finland

In Finland, no detailed statistics on the waste amounts of different types of naturally occurring masses generated in construction exist. The data available is limited to the EWC-Stat categories of the EU Waste Statistics. The data relevant for this study, i.e. manufactured mineral materials excluded, retrieved from Statistics Finland (2020) is presented in Table 14. According to the Finnish waste statistics, the amount of landmass waste generated in construction activities in Finland was around 14 Mio tonnes in 2018. However, it should be noted that the statistical data on waste amounts is not fully comprehensive and reliable. In several Finnish sources it is reported the total amount of waste soils and rocks generated in construction is significantly higher than reported in the statistics, around 20–30 Mio tonnes annually. Some of the surplus masses generated in construction are utilised in earthworks or landfill constructions subject to the environmental permits, but masses are generated, and they are used also in significant amounts outside the activities subject to environmental permits, and their quantities are not systematically followed or compiled in statistics (Järvinen 2018).

Table 14 Mapping of relevant materials in Finland (such as soil, rock, sediments, other naturally occurring materials) with respect to types, amounts, level of pollution, and in what type of activity there are generated.

Material types	Waste amounts Mio tonnes/year	Level of pollution	Type of activity
Soils E.g. soil and stones, incl. excavated soil from contaminated sites	13.9 ¹	Non-hazardous	Construction and demolition Soil remediation (Civil engineering, demolition and site preparation)
Soils E.g. soil and stones, incl. excavated soil from contaminated sites	0.1 ¹	Hazardous (containing oil, heavy metals, organic pollutants)	Construction and demolition Soil remediation (Civil engineering, demolition and site preparation)
Dredging spoils	0 ¹	Non-hazardous	Construction and maintenance of water project, dredging and subsurface work
Dredging spoils	0.002 ¹	Hazardous (containing heavy metals or organic pollutants)	Construction and maintenance of water project, dredging and subsurface work
Total	14.0		
Surplus masses	20–30²	-	All construction activities

¹ Source: Statistics Finland 2020, data from 2018.

² Estimate based on waste statistics and supplementary estimates given by the experts (e.g. Koivuniemi 2013, Ministry of the Environment 2016, Pyy et al. 2017, Järvinen 2018).

According to the statistics, the amount of landmass waste generated in construction activities in Finland between 2015–2018 has varied from 12 Mio tonnes in 2016 to 14 Mio tonnes in 2018 (Figure 6).

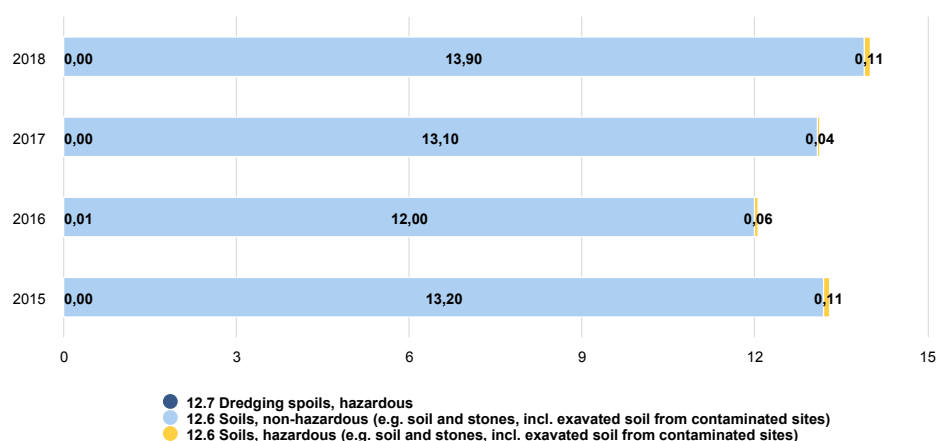


Figure 6 Waste masses generated in construction between 2015–2018 (Statistics Finland 2020).

Although statistics give only overall level information on the generation of surplus masses in Finland, some regional estimates are nevertheless available. According to CircHubs (2018), in the Finnish capital region, which consists of the four cities – Helsinki, Espoo, Vantaa and Kauniainen – around 4.4 Mio tonnes of surplus landmasses were generated in earthworks and hydraulic engineering in 2016. These waste masses are mostly clays (Inkeröinen & Alasaarela, 2010). In Turku region the estimated waste amount is 0.35 Mio tonnes, and similarly in Tampere region, the amount in 2015 was around 0.35 Mio tonnes (CircHubs, 2018). In Tampere region, surplus masses are mostly rock aggregates and moraine (Inkeröinen & Alasaarela, 2010).

Surplus soils in Finland are typically mud, clay and silt that cannot be utilised, or coarser non-cohesive soils such as moraine, large rocks and blocks. If future land use planning and regional construction do not take surplus masses into consideration purposefully, it is estimated that particularly the amount of surplus clay will increase as construction sites are located in geotechnically weaker areas (Koivuniemi, 2013). Most of technically poor-quality surplus soils are disposed to landfills in Finland. Also, good quality unspoiled landmasses are often being landfilled, if their direct utilisation is not planned or possibility to longer term temporary storage does not exist. (Ministry of the Environment, 2016).

In addition, there are acid sulphate soils especially in the Finnish coastline, whose geotechnical quality is usually poor (e.g. due to their organic matter content), and, when oxidised, form acidic runoff and metal emissions. The presence of acid sulphate soils and potential acid sulphate soils should be identified and taken into account already at a very early stage of the circular economy earthwork projects. The challenges and requirements caused by their acid generation potential must be taken into consideration when reusing and recycling these soil masses (Auri et al. 2020).

According to the statistics, in 2018 in total 20.3 Mio tonnes of waste landmasses were treated in Finland. 82% (16.6 Mio tonnes) were being landfilled, whereas the share of material recovery was 16% (3.2 Mio tonnes), and other disposal operations accounted for 2% (0.4 Mio tonnes) (Statistics Finland, 2020) (Figure 7). Surplus masses can be utilised e.g., in noise barriers, landfill constructions, landscaping and park construction, landfill mounds, street structures, shoreline filling, and levelling and raising building sites (Koivuniemi, 2013). However, it should be noted that the waste statistics only cover fractions that have ended up as waste, and not materials that are e.g. utilised on site, i.e. non-waste materials.

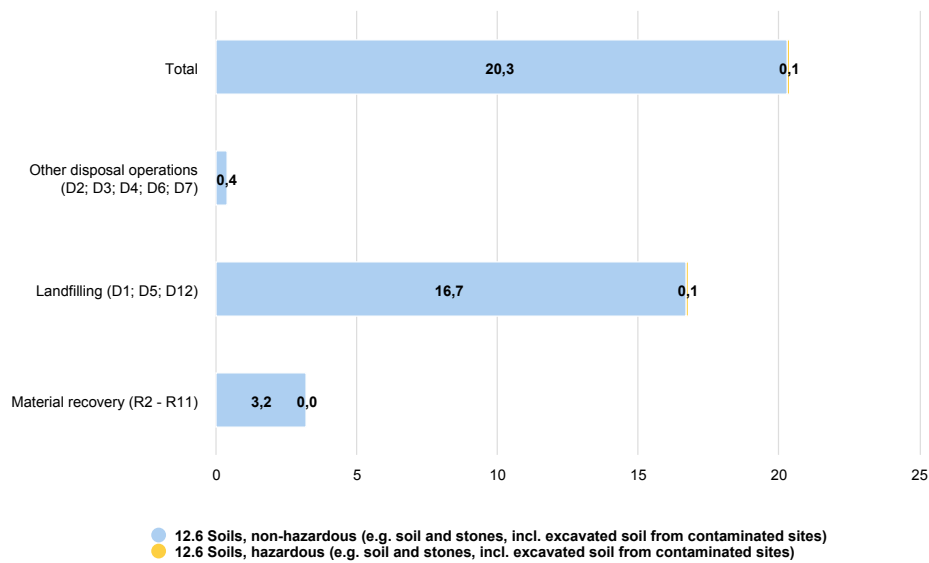


Figure 7 Treatment of landmasses generated in construction in Finland in 2018 (Statistics Finland 2020). Recovery (R) and disposal (D) codes are defined in the EU Waste Framework Directive 2008/98.

Comprehensive information on the management of materials in Finland does not exist on national level. However, some case examples on the management of surplus masses in different cities are available and collected in Table 15. Yearly more than 800,000 m³ of uncontaminated surplus landmass is generated in Helsinki as a result of construction activities. Helsinki has a development a program ongoing for land mass coordination, in which around 5.3 Mio tonnes of landmasses have been reused in construction projects between 2014–2019 (City of Helsinki (n.d.)). Currently, around 80% of surplus landmasses generated annually are utilised in Helsinki. The remaining 20% are clays and mud which utilisation is not yet possible, and they are being landfilled outside the city (Moilanen, 2020). Better utilisation and reduction of the used amounts of surplus landmasses has led to savings between 5–10 Mio € per year for the city of Helsinki (City of Helsinki (n.d.)).

The city of Hämeenlinna has carried out several pilot projects regarding to landmass utilisation. The aim is that these new practices will gradually become a part of normal operations. Before starting the projects, around 28% of the masses were utilised in Hämeenlinna, but in 2019 the share was increased already to 62%.

Table 15 Management of relevant masses in Finland.

Type of material	Amount	Level of pollution	Purpose of application	Information on transport and costs
Examples from Helsinki				
Surplus landmass, not specified ¹	1.869 Mio tonnes in 2019 5.3 Mio tonnes between 2014–2019	Uncontaminated	The reuse and utilisation of surplus masses in construction: - Utilization in planning of streets and parks. - Reuse of surplus masses and crushed concrete (0.1 Mio tonnes) to avoid the use of natural resources. - Pilot projects: - Dumping site landscaping (Vuosaari) - Parks (Alakivi Park and Ida Aalberg Park, see below) - Construction sites along the coastline (fill sites) - Noise barriers (Sepänmäki and Jakomäki)	Savings 2014–2019: 47 Mio €, 6.9 Mio litres of fuel + 17,100 tonnes of CO ₂ emissions
Mass stabilised dredging spoils (35,000 m ³), and topsoils (25,000 m ³) ^{2, 3, 4}	0.06 Mio m ³	-	Myllypuro, Alakivi park, Helsinki: Old landfill was reconstructed as a park. Mass stabilised dredging spoils were used in landscaping, topsoils in forming growth medium. Also crushed concrete was utilised. Spoiled masses were mostly placed inside 20 m high cone	Costs 2.5 Mio € (around 22 €/m ²) Savings 3.8 Mio €, 400,000 litres of fuel + 1,000 tonnes of CO ₂ emissions
Blasted rock ⁴	1 Mio m ³	-	Koirasaari, Helsinki: filling of the dredged area (10 ha)	Costs 13 Mio € Savings 20 Mio €, 3 Mio litres of fuel + 8,000 tonnes of CO ₂ emissions
Excavated landmasses ⁵	0.45 Mio m ³	Uncontaminated (0.35 Mio m ³), contaminated (0.1 Mio m ³)	Hyväntoivonpuisto (park), Helsinki: Excavated landmasses generated in Länsisatama (West harbour) construction area utilised in park construction. Spoiled soils capsuled.	Savings 8.3 Mio €, 165,000 litres of fuel + 410 tonnes of CO ₂ emissions
Non-cohesive soils, clay, sediments (stabilised and unstabilised), topsoil ^{5,6}	0.015 Mio m ³	-	Ida Aalberg park, Helsinki: former shooting range, removal of contaminated soil (6,000 tonnes), filling with surplus soils, surface shaping with topsoils	Costs 13 Mio € Savings 20 Mio €, 3 Mio litres of fuel + 8,000 tonnes of CO ₂ emissions

Examples from Hämeenlinna

Surplus landmass, not specified ⁷	0.0971 Mio tonnes in 2019 in 5 pilot projects (see below)	-	E.g., pre-construction of the building site, temporary storage for later use, old structural layers used for maintenance, recycling onsite	Total savings 346,700 €, of which 122,200 € in transport, reduction in transport 62,600 km
Surplus landmass, not specified ⁷	0.07 Mio tonnes	-	Painokankaanmäki, Hämeenlinna: pre-construction of the building site (short distance). Surplus masses generated 96,000 tonnes in total	Savings: landfill savings 163,300 €, transport 94,000 €, reduction in transport 43,100 km + 27.9 t of CO ₂ emissions
Surplus landmass, not specified ⁷	0.0158 Mio tonnes	-	Kitkamaankatu, Hämeenlinna: temporarily stored for later use. Surplus masses generated 15,800 tonnes in total.	Savings: landfill savings 36,800 €, transport 22,800 €, reduction in transport 15,800 km + 10.2 t of CO ₂ emissions
Surplus landmass, not specified ⁷	7,300 tonnes	-	Ojoinen, Hämeenlinna: temporarily stored for later use. Surplus masses generated 39,500 tonnes in total.	Savings: landfill savings 17 000 €
Surplus landmass, not specified ⁷	3,000 tonnes	-	Asevelikylä, Hämeenlinna: old structural layers used for maintenance. Surplus masses generated 37,600 tonnes in total.	Savings: landfill savings 7,000 €, transportation 2,500 €, reduction in transport 1,700 km + 1.1 tonnes of CO ₂ emissions
Surplus landmass, not specified ⁷	1,000 tonnes	-	Taula-matintie, Hämeenlinna: recycling and temporarily storing onsite. Surplus masses generated 3,400 tonnes in total.	Savings: landfill savings 2,300 €, transport 1,000 €

Sources:

¹City of Helsinki (n.d.), ²Ramboll (n.d.), ³Yli-Jama 2017, ⁴Suominen 2019a, ⁵Suominen 2019b, ⁶Arrakoski 2019, ⁷CircWaste 2020

4. Policy instruments and risk assessment

Based on our expert knowledge and the information gathered during this project we know that the management of naturally occurring materials is subject to a complex set of national regulations and that different approaches are applied in the management and especially risk assessment of naturally occurring materials.

When gathering and describing relevant national regulations, approaches to risk assessment, guidance documents and strategies, we have placed emphasis on limiting the description to the most central information. Nevertheless, it adds up to a great deal of complex information for the reader. As we would like to analyze and evaluate differences and similarities between the Nordic countries, with a view to preparing some recommendations for authorities and operators, we have chosen to present the more descriptive information on relevant policy instruments and strategies etc. in appendix 2 and highlight the most important differences and similarities in the Nordic countries in this chapter.

Appendix 2 also contains information on relevant national strategies, guidance documents and existing descriptions of best practise, as far as those are available.

Based on the gathered information, the most important similarities and differences are analysed and described in the following sections:

- **National policy instruments:** What are the similarities and differences between the relevant national policy instruments and what are the lessons learned from that? Is there information on new/upcoming relevant legislation and guidance in the Nordic countries?
- **Challenges of waste statistics:** To what extend are national waste statistics a suitable tool to provide a detailed overview of amounts and management of naturally occurring materials?
- **Management of material:** In this section we focus on the similarities and differences in the management of naturally occurring materials. Which materials are handled in a relevant and suitable way and which materials represent a problem?
- **Waste status:** The classification of naturally occurring materials as waste or non-waste has an impact on which legislation applies in the management of materials, which in turn has an influence on the need or requirement for permits, approvals etc.
- **Approaches for risk assessment:** To what extend and how is risk assessment applied in the management of the relevant wastes and materials? Are slightly contaminated materials in an urban environment treated differently from unpolluted/virgin material? Is there a difference in assessment and management of materials, depending on whether they are used on-site (e.g. in the same project again) or used at another location?

4.1. National policy instruments

Based on the information gathered and described in appendix 2, we can see, that the management of naturally occurring materials in the Nordic countries is regulated by a complex set of legislation which is based on, but not exclusive, environmental legislation, waste legislation, soil legislation, land use and building regulations. The management of materials requires either notification to authorities or permits. Although specific legislation on soil exists in all countries, there is no single, specific legislation for the management of rock masses from either drill and blast activities or TBM. We would like to ask the reader to take a closer look at Appendix 2 for information on specific laws or executive orders in the different countries.

In all Nordic countries underlying sets of guidance documents and handbooks exist, however, to varying degree. The classification of naturally occurring materials as waste or non-waste in accordance with the national waste legislation is of great importance for the management of materials. This is explained in further detail in section 4.4.

In **Denmark**, where excavated soil is the most important naturally occurring material stream to be managed, specific regulations regarding the classification, excavation and removal of soil exist. They contain a system for notification to local authorities, classification system for excavated soil, including limit values to be used in this context as well as sampling and classification instructions. Furthermore, specific regulation for the use of soil in construction and infrastructure projects exists. Depending on the degree of pollution of excavated soil, which is determined by sampling and testing by total content analysis and leaching test, utilisation in restricted applications is possible with notification to local authorities. Utilisation in larger projects typically requires a permit from local authorities according to environmental legislation. In order to acquire a permit, site-specific risk-assessment is needed to determine the expected risks for soil and groundwater pollution at the site, where materials are to be received and managed. However, there is no specific legislation or guidance on how risk assessment is to be carried out. Also waste legislation and land use and planning legislation are relevant in the management of naturally occurring materials. There is no specific regulation for other types of naturally occurring materials, such as TBM masses or rock masses in Denmark.

In **Sweden**, there is no material specific legislation for the management of naturally occurring materials. All other types of naturally occurring materials are subject to environmental, waste (in case the materials are classified as waste), land and building legislation with underlying sets of regulations, handbooks, and guidelines. For the management of naturally occurring materials (excluding masses classified as "less than low risk" (Naturvårdsverket, 2010)), environmental permits and/or notifications are mandatory and those are based on risk assessment. Use and classification of the materials is evaluated based on risk for human health, the environment and natural resources in contact with the materials. Furthermore, land use classification with general or site-specific guideline values for contaminants in masses applies. National guidelines, e.g. to determine waste/by-product status, guidelines for management of materials, and guidelines for contaminated soils has been developed.

Masses with classification as waste can also be re-used. If the masses/waste can be

re-classified for land use off-site according to the guidelines for contaminated land. The levels for land use (sensitive and less sensitive land use) can be applied with approved notification to the local or regional authorities. Also waste treatment activities can be used to wash and separate the waste into new fractions of masses/soil as for reclassification of masses above.

Work is ongoing regarding **Swedish guidelines, handbooks and other legal documents** from agencies regarding handling of masses, by-products and waste. The Swedish Building Act is also updated with a section at the time. Publication of the new documents is due later in 2021.

The management of naturally occurring materials in **Norway** is regulated by several sets of regulations across sectors - environmental legislation, waste legislation, planning and building, agriculture, and by several authorities at both national, regional, and local level. For the utilisation of surplus materials, a permit from the national authority is needed unless nationally defined criteria are fulfilled for the materials and the site of application itself. Disposal of materials is regulated according to the planning act in addition to environmental protection legislation. There is no special legislation for the different types of uncontaminated naturally occurring materials, except for acid forming shale. However, for contaminated sites and acid-forming shale, a classification system exists. Guidance on the management of naturally occurring materials and the defined criteria for exception from the application for utilization off site exists via the Norwegian EPA Guidance on the Pollution Control Act's requirements for intermediate storage and final disposal of soil and rock masses that are not contaminated (Miljødirektoratet, 2021a).

The **Norwegian EPA is currently working on an Act** to regulate the management of excess unpolluted materials generated in construction activities. As mentioned in Table 3, a cross-sectoral project will be implemented that looks at possible measures and instruments to achieve better management of non-contaminated surplus masses of soil and rock and a smoother process regarding permits to utilise the materials. The project involves 11 directorates and agencies that have been commissioned by their ministries to contribute to the project within their fields. A report is expected in September 2021.

In **Finland**, the management of naturally occurring materials is regulated via environmental legislation, waste legislation, land use and building as well as soil legislation. There is no specific legislation for the different types of naturally occurring materials, other than soil legislation. Management of naturally occurring materials, that are classified as waste and therefore may pose a risk of environmental pollution requires an environmental permit, e.g., soil landfill sites. Risk-based soil screening values are applied in assessment of soil contamination. Furthermore, e.g., guidelines for risk assessment, assessment of waste status and preliminary operations model for the management of stony materials exist.

In **Finland**, a revision of the **Land Use and Building Act** is currently underway. The goal is that the government proposal for a new Land Use and Building Act will be completed by the end of 2021 (Ministry of the Environment, 2021). It is planned that the temporary storage of uncontaminated soils could be handled by a building permit for temporary construction under the upcoming Land Use and Building Act, which will replace e.g. the current action permit used for temporary storage in

certain cities. The idea is that such permit would allow the temporary storage of non-polluted masses as non-waste before their utilisation, even if the final use of the mass is not known yet. The current general interpretation is that the mass must then be regarded as waste, although in certain cities temporary storage without knowledge of the final use is possible with an action permit. Thus, the new soil regulation under the Environmental Protection Act, supplemented by the MASA Degree, would only apply to those masses whose use/disposal may pose a risk of environmental pollution, i.e. pollutants, wastes, or masses with acid generation potential above the threshold values (Reinikainen, 2021).

Between 2015–2018 Ministry of the Environment and Finnish Environment Institute (SYKE), prepared a proposal called “**Government decree on utilization of soil waste in earthworks (MASA-asetus)**”. The general objective of the proposed decree was to promote a safe utilisation of the soil generated in construction and similar activities that can be classified as waste, and waste suitable as a binding agent for stabilisation of soil. After being circulated for comment, the proposal received around 50 statements, in which notable revisions were proposed. Due to this as well as certain challenges recognized during the preparation process, it was considered necessary to consider other regulatory options to promote the utilisation of surplus landmasses. During 2020, a new alternative legislative solution was created that is based on supplementing the Environmental Protection Act (527/2014) with general provisions concerning surplus landmasses, including procedural provisions, as well as drafting of a Government Decree specifying them (“MASA 2.0”). The key aspects of the new regulation are the obligation to investigate soils that are being potentially harmful or cause danger of environmental pollution, and a notification procedure concerning their excavation, utilisation, stabilization, and intermediate storage. The Government’s proposal and decree are scheduled for the spring 2022 (Ministry of the Environment, 2020; Reinikainen, 2020).

4.2. Challenges in waste statistics

Due to geographical differences between the Nordic countries, there are natural differences with respect to the types and amounts of materials, that need to be managed in the Nordic countries. The mapping of relevant materials showed, that excavated materials such as a mix of soil and other mineral masses is the most dominating fraction in Denmark and Finland, whereas rock masses from drilling and blasting activities as well as tunnel boring machines constitute significant quantities in Norway and Sweden.

In general, it can be said, that the national waste statistics are a poor tool to provide a detailed overview of amounts of materials and their management in practise. The statistics do not reflect the different types of materials and their respective geotechnical properties either. Statistics of natural occurring materials are relatively poor both with respect to amounts registered as well as type of masses and their management:

- **Background for statistics:** Typically, national statistics are generated because of requirements in waste legislation. As a result of that, they only cover waste fractions that need to be reported and do not contain information on materials, that are not regarded as waste streams, e.g., because they are utilised on-site.

Moreover, there are differences in scope for the statistics, e.g., in Norway only polluted materials are to be registered.

- **Amounts:** There are different requirements and practise of generating statistics in the Nordic countries. In Denmark statistics comprise information on actual waste amounts handled and information on the intended waste management. In Sweden, on the other hand, the national waste statistics regarding naturally occurring materials only include waste received by waste management facilities which are obligated to send in an environmental report. Thus, waste amounts received at other waste management facilities are not included. Materials that are used on-site are typically not registered at all.
- **Level of detail:** Waste statistics typically use pre-defined waste categories. That does not reflect the actual materials and their properties. Natural occurring materials are to a limited extend covered – "soil and stones" is one waste type that is covered in the Nordic countries under "construction and demolition wastes" and thus follows the European list of waste. However, other types of materials, such as rock masses from tunneling and similar infrastructure projects, may not necessarily be covered.
- **Management:** In national statistics, the management of materials is registered in terms of predefined recovery or disposal operations and lacks the level of detail to determine what types of materials and to what extent are utilised on-site, off-site, in landscaping projects, infrastructure projects, agricultural purposes.

4.3. Management of materials

The mapping of naturally occurring materials in terms of waste statistics, material management, has given information on several aspects, that we presented in chapter 3. In this section, however, we present similarities and differences in the Nordic countries and focus on the following:

- Which are the most important waste streams in the Nordic countries?
- How and where are the materials utilised?
- What differences in management of unpolluted/virgin materials and slightly polluted materials can be seen?
- Where do we see potentials for optimised management?
- Why is this not happening in practise? What is preventing the optimised management?

As shown in Table 16 there are substantial differences in the amount of naturally occurring materials that are managed on an annual basis. Whereas excavated soil is dominating in Denmark and Finland, excavated masses and rock masses from drill and blast activities as well as TBM are the predominant fractions in Sweden and Norway. As explained in the previous sections, national waste statistics are a poor tool to provide a detailed overview of amounts of materials and their management in practise. Statistics of natural occurring materials are relatively poor both with respect to amounts registered as well as the level of detail and management. Moreover, materials, that are used on site are typically not registered at all.

Consequently, it is difficult to get a good overview of important material streams, how they are managed and how large the potential for optimised management is.

Based on the gathered information it can be said that there is a potential for optimised management of naturally occurring materials in the Nordic countries. However, based on the available data and information it is not possible to give a quantitative estimate on how large this potential is.

Table 16 Comparison of similarities and differences in amounts and management of materials in the Nordic countries. Figures are based on the information that was presented and discussed in chapter 3.

Denmark	Finland	Sweden	Norway
15 Mio tonnes soil	20–30 Mio tonnes soil	35 Mio tonnes excavated masses 12.5 Mio tonnes soil 10–20 Mio tonnes mechanically excavated masses	11–21 Mio tonnes mechanically excavated masses 2.15 Mio tonnes soil Estimated total of 40–50 Mio tonnes unpolluted excavated masses
80% recovery 20% disposal	20% recovery 80% disposal (according to waste statistics)	No detailed information due to poor statistics.	No detailed information on utilization, but we estimate 20% recovery 80% disposal
Potential for optimized management			

Estimation of potential for CO₂-savings for optimized management

Transport distances play an important role in the management of naturally occurring materials. It is typically rather costly to transport materials over longer distances. Reduction in transportation of materials has a potential for economic savings. Moreover, the use of excavated materials on-site or very close to the site of excavation, offers great potentials for CO₂-savings, if transport of the materials can be reduced or even avoided.

Based on the gathered data in this project, we have estimated, that approx. 133 Mio tonnes naturally occurring materials are managed every year. Under the assumption, that materials on average are transported 20 km, this adds up to 2660 Mio tonnes km of transport every year.

	Amounts Mio tonnes
Denmark	15
Finland	20
Sweden	58
Norway	40

Drastic reduction in transportation of naturally occurring materials, for instance by increased use of materials on-site, may offer potential CO₂-savings in the Nordic countries. In our calculation we have estimated an annual potential for CO₂-savings of ca. 240 000 tonnes CO₂ -eq.

Emission factor TF1 truck (Danish Transport, Construction and Housing Authority, 2020)	0.0897	kg CO ₂ -eq / ton km
Total amount in the Nordic countries:	1.33E+08	tonnes
Average transport distance (the authors' assumption):	20	km
Average ton km:	2.66E+09	ton km
Average CO ₂ emission:	2 E+08	kg CO ₂ -eq
Annual potential for CO ₂ -savings:	240000	ton CO₂ -eq

In **Denmark**, both unpolluted and slightly polluted soil are utilised in construction projects, such as noise barriers, terrain regulation, land reclamation. Although a large proportion of excavated soil is utilised, there is potential for optimisation. Transport distances play an important role and represent a barrier for the optimised management. It is typically too costly to transport excavated soil over larger distances (Danish EPA, 2020). This results in disposal of larger amounts of soil as compared to polluted soil. In that respect longer transport distances represent a barrier for utilisation of soil. The local utilisation of soil not only offers great potential for efficient use of resources and reduction in environmental impacts, but it also offers potential for costs savings as well. In a study carried out for the Central Denmark Region, it has been estimated that local utilisation of soil, i.e., utilisation on-site or nearby, compared to disposal at soil management facilities can generate up to 50% costs savings (NIRAS, 2018).

Surplus soils in **Finland** consist typically of mud, clay, silt, or coarser non-cohesive soils such as moraine, large rocks, and blocks. Especially mud, clay and silt represent a problem in **Finland** since they are difficult to utilise. Also, acid sulphate soils represent a challenge. Table 16 indicates that only 20% of excavated soil is recovered. However, it should be noted that this only covers fractions that have ended up as waste, and not materials that are e.g., utilised on-site or off-site, i.e., non-waste materials. Actual management may be better as compared to reported figures in the statistics. Estimates from local/regional projects indicate that higher recovery rates are possible, e.g., in Helsinki currently around 80% of surplus landmasses generated can be utilised.

Slightly pollutes materials are more prone to end up in landfills in **Norway**. TBM masses are typically regarded of lower quality as compared to rock masses from drill and blasting and are typically landfilled. TBM masses typically require reprocessing before use as additive in concrete is possible. In **Norway** masses from highway and railroad projects have historically been regarded as a problem rather than a resource and have been disposed of in the cheapest manner. This is about to change because of the implementation of the circular economy mindset in Norwegian legislation, regional and local regulations and mindset and standards in the engineering, procurement, and construction phase of the C&D industry.

Pollution in rock masses from blasting

In Norway, there has been a lot of attention about plastic pollution in the sea due to foreign substances in rock masses blasted with explosives. Previously, electric detonators were used that were connected to thin electrical wires. Today, the boreholes are filled with dynamite or ANFO (Ammonium nitrate fuel oil), and hollow plastic hoses (NONEL – non-electric detonator) with a diameter of 3.5 mm are used with explosives on the inside. When the charge goes off, the NONEL hoses are blown into thousands of pieces, which accompany the blasted rock out of the tunnel. If the blasted rock is dumped into the sea, the plastic pieces will float up and pollute beaches in a large area. It is very difficult to clean away the plastic pieces - it requires crushing and sieving the masses.

The Norwegian Environment Agency has made a calculation of the amount of plastic that emerges. A 60 km long tunnel will produce 27 tonnes of plastic from NONEL ignition systems, and if plastic is used as fibre reinforcement in the concrete, an additional 85 tonnes of plastic will be generated, i.e., 112 tonnes of plastic, which is normally deposited in the sea.

Explosives can be either ANFO or nitro-glycerine. ANFO is 95% ammonium nitrate and 5% diesel, and both types of explosives therefore contain a lot of nitrogen. Nitrogen acts as a fertilizer in fresh water, and with incorrect blasting techniques and vulnerable water recipients, blasting work can lead to water pollution and damage to the ecosystem, in worst case death of fish and shellfish. The detonators used are normally disintegrate during the explosion. Sometimes one finds detonator bottoms in the rock masses. In some contexts, delay systems are used on the ground, and these rarely disintegrate (Harstad, 2021).

4.4. Waste status

The classification of naturally occurring materials as waste or non-waste/resource is of great importance for the management of the materials. This does not mean that the materials must not or cannot be utilized. A waste material may still be recovered or recycled. However, the fact that a material is classified as waste means that it is subject to the waste rules and the consequences that this entails for approvals, permits, compliance with relevant limit values, fees and taxes and the like.

This has a great influence in practice on the timeframe for decisions such as permits or approvals, which in turn has a strong influence on costs and consequently choices and possibilities for material management. This presupposes that the contractors have sufficient knowledge and expertise to be able to assess whether a material is waste or not in a given situation in order to be able to apply for permits or whatever may be relevant.

Therefore, the following section focuses on the waste status of naturally occurring materials:

- To what extent are naturally occurring materials covered by the European waste framework directive (WFD)?
- Under what circumstances are naturally occurring materials considered waste?
- Are uncontaminated materials classified differently from contaminated materials?

According to the WFD "uncontaminated soil and other naturally occurring material excavated in the course of construction activities where it is certain that the material will be used for the purposes of construction in its natural state on the site from which it was excavated" are excluded from the scope of the directive – hence they are not regarded waste. As can be seen, several factors have to be fulfilled when it needs to be determined, whether naturally occurring materials are excluded from the scope of the WFD, such as use on-site and the certainty of use. The Nordic countries follow this requirement of the WFD. Moreover, the Nordic countries have incorporated the definition of waste, as given in the WFD, in the national waste legislation.

In Table 17 and Table 18 above we have presented information on the classification of naturally occurring materials as waste/non-waste in case materials are used on-site and off-site, respectively. This information is based on the classification of naturally occurring materials as defined in the national legislation in the Nordic countries.

As can be seen from the information in the tables, there may be circumstances, where classification in practice deviates from the general classification. The information on these circumstances and situations in practice where the classification deviates from the rule is added by the authors based on our expert knowledge as well as relevant references.

In many cases it is easy to determine whether a material is considered a waste. However, there may be circumstances, where this is more difficult. What happens if soil or other such material temporarily is taken from a construction site and returned later and used on the site for the purposes of construction? From a legal point of view, limitations regarding storage time typically exist, but what happens if soil or other such material is stored on site for an unspecified period but with the intention to use it on site? Are stakeholders, such as operator or contractors aware of these differences?

Table 17 and Table 18 indicate the typical classification as waste or non-waste for how different types of naturally occurring materials. Whereas Table 17 shows the classification for on-site use of materials, Table 18 indicates classification for off-site use of materials.

Table 17 On-site use of naturally occurring materials and classification as waste or non-waste in the Nordic countries.

On-site use	Denmark	Sweden	Norway	Finland
Unpolluted soil	Not waste. Under certain circumstances waste.	Not waste. Under certain circumstances waste, such as when the natural levels of sulfides and ammonium are high which makes it difficult to use generated soils, it is considered as waste.	Not waste. But if you establish an on-site landfill for excess soils, it will be regarded as waste.	Not waste (if the further use is certain, systematic, and the material can be used directly without any further processing).
Polluted soil	In principle regarded as waste; under certain circumstances non-waste; level of pollution determines the possible use.	The level of contamination is the limiting factor in the classification. High levels are in principle regarded as waste. Low levels under certain circumstances are considered as non-waste.	Not waste. Can be reused on-site, if the concentrations are below acceptable limits (defined in national guidelines). If the masses are polluted above acceptable limits, the holder is required to discard them.	Waste, if concentration exceeds the threshold value or the background concentration in cases where background concentration is higher than threshold value
Excavated masses (unpolluted)		Not waste, under certain circumstances waste.	Not waste, unless you establish a landfill on-site.	Not waste (if the further use is certain, systematic, and the material can be used directly without any further processing).
Excavated masses (polluted)		The level of contamination is the limiting factor in the classification. High levels are in principle regarded as waste. Low levels under certain circumstances are considered as non-waste.	Not waste. Can be reused, if the concentrations are below acceptable limits (defined in national guidelines).	Waste, if concentration exceeds the threshold value or the background concentration in cases where background concentration is higher than threshold value.
Rock masses from drilling and blasting (unpolluted)		Not waste, under certain circumstances waste.	Not waste. Plastic waste from blasting must be assessed as well as chemical pollution.	Not waste (if the further use is certain, systematic, and the material can be used directly without any further processing).
Rock masses from drilling and blasting (polluted)		The level of contamination is the limiting factor in the classification. High levels are in principle regarded as waste. Low levels under certain circumstances are considered as non-waste.	Not waste. Can be reused, if the concentrations are below acceptable limits (defined in national guidelines). The sulphide content, explosive agents' residues (nitrogen compounds) and plastic waste from blasting must be assessed as well.	The level of contamination is not normally determined. However, the authority may require that the sulphide content and explosive agents' residues (nitrogen compounds) are assessed.
TBM-rock masses (unpolluted)		Not waste, under certain circumstances waste.	Not waste.	Not waste.
TBM-rock masses (polluted)		The level of contamination is the limiting factor in the classification. High levels are in principle regarded as waste. Low levels under certain circumstances are considered as non-waste.	Not waste. Can be reused, if the concentrations are below acceptable limits (defined in national guidelines).	The level of contamination is not normally determined. However, the authority may require that the sulphide content and explosive agents residues (nitrogen compounds) are assessed.

Table 18 Off-site use of naturally occurring materials and classification as waste or non-waste in the Nordic countries.

Excess/surplus material; off-site utilization	Denmark	Sweden	Norway	Finland
Unpolluted soil	In principle regarded as waste; under certain circumstances non-waste.	In principle regarded as waste; under certain circumstances non-waste.	Waste.	Not waste (if the further use is certain, systematic, and the material can be used directly without any further processing).
Polluted soil	In principle regarded as waste; under certain circumstances non-waste.	In principle regarded as waste.	Waste.	Waste, if concentration exceeds the threshold value or the background concentration in cases where background concentration is higher than threshold value.
Excavated masses (unpolluted)	In principle regarded as waste; under certain circumstances non-waste.	In principle regarded as waste; under certain circumstances non-waste.	Waste.	Not waste (if the further use is certain, systematic, and the material can be used directly without any further processing).
Excavated masses (polluted)	In principle regarded as waste, under certain circumstances non-waste.	In principle regarded as waste	Waste.	Waste, if concentration exceeds the threshold value or the background concentration in cases where background concentration is higher than threshold value.
Rock masses from drilling and blasting - (unpolluted)		In principle regarded as waste; under certain circumstances non-waste.	Waste.	Not waste (if the further use is certain, systematic, and the material can be used directly without any further processing).
Rock masses from drilling and blasting - (polluted)		In principle regarded as waste.	Waste.	The level of contamination is not normally determined. However, the authority may require that the sulphide content and explosive agents' residues (nitrogen compounds) are assessed.
TBM-rock masses (unpolluted)		In principle regarded as waste, under certain circumstances non-waste.	Waste.	Not waste.
TBM-rock masses (polluted)		In principle regarded as waste.	Waste.	The level of contamination is not normally determined. However, the authority may require that the sulphide content and explosive agents' residues (nitrogen compounds) are assessed.

The examples in Table 19 are based on information in literature, from practitioners and guidance documents. The examples highlight situations and circumstances that may make it difficult to determine waste status. This is not an exhaustive list but merely illustrates some relevant situations.

Table 19 *Examples of situations when naturally occurring materials fall within and outside the waste definition.*

Material	Example of situation	Applicable country
Surplus soil from excavation activities	There is basically a need for and desire to dispose of the material. E.g., surplus soil that has been excavated to enable the establishment of, for example, major building and construction work must be presumed to be waste, as there is a need for and thus a desire to dispose of the soil (Brandt, 2019).	Denmark, Sweden, Norway
Excavated soil	In situations where the client or contractor contacts the municipality for instructions on how and where to dispose of excavated soil, it must also be assumed that it is waste, as the owner intends to dispose of the material.	Denmark, Norway, Sweden
Surplus soil from excavation activities is transferred to another project	In case that unpolluted surplus soil is transferred from one project to another construction project and the agreement on the transfer of soil has been entered into no later than at the time of excavation, and the soil is only stored for a shorter period before utilization, soil is not regarded as waste.	Denmark, Finland, Norway
Surplus soil from excavation activities is stored for an unspecified period.	Surplus soil from an excavation cannot be used on site and needs to be stored for an unspecified period (i.e. the soil use is not certain). Therefore, soil will be assumed to be waste.	Finland, Sweden, Norway
Unpolluted TBM-rock masses and rock masses from drilling and blasting that are to be used on-site.	In Sweden there are cases where the court has decided that rock masses that would not be used within the project could be classified as by-products. This if they needed to meet the criteria in chapter 15 and paragraph 1 of the Environmental Code (Nacka tingsrätt, 2014).	Sweden, Norway
Unpolluted masses (rock material or soil) with natural high concentrations of sulfides	If necessary protective measures mean that the use of the masses is not technically feasible or economically reasonable, the masses are considered as waste.	Sweden, Finland case specific, Norway

4.5. Approaches for risk assessment

The following section describes how and to what extent risk assessment is applied in the management of relevant materials in the 4 Nordic countries. In other words, a description is given of how to assess potential risks associated with the utilisation of materials either on-site, where they have been excavated, or off-site in another projects or application. This analysis will give answers to questions such as:

- What kind of approach to risk assessment is used in the Nordic countries?
- Are slightly contaminated materials in an urban environment treated differently from unpolluted/virgin material?
- Is there a difference in assessment and management of materials, depending on whether they are used on-site (e.g., in the same project again) or used at another location?

The term "risk assessment" refers to a process where environmental data are collected, organised, and analysed to estimate the risk of undesired effects on organisms, populations or ecosystems caused by various stressors associated with human activity (Pérez & Eugenio, 2018). Risk assessment is widely used to address soil contamination and is usually part of a process starting with a suspicion of soil contamination, followed by a site investigation to confirm contamination and finally the assessment of whether the level of contamination poses a significant risk to human health and the environment.

However, risk assessment is also used to determine the potential risks associated with the utilisation of materials from a specific site, on-site or off-site. In this context, it is referred to as site-specific risk assessment.

4.5.1. Main approaches and legal framework for risk assessment of contaminated sites

The legal framework for management of soil contamination and remediation of contaminated sites varies across the Nordic countries. Different approaches to setting background or reference values, defining sampling and testing strategies as well as statistical treatment of results from sampling are used. However, the types of legal instruments applied, how the identification and registration of soil contamination is done, and which limit values are applied have a natural influence on how excavated soil and other naturally occurring materials are managed. Therefore, a brief description of the systems used in the 4 countries is included in Table 20. The information in the table is based on Pérez & Eugenio (2018) and supplemented with information gathered in this project. In Appendix 2 the reader can find additional and country specific information on the requirements for risk assessment etc.

All four countries have legal instruments and guidance in place that focus on soil protection to prevent (further) contamination and the management of contaminated sites, respectively. This legal framework thus covers the assessment of masses prior to excavation, such as excavation of soil, decomposed bedrock, gravel, sand etc. However, there are distinctions between assessment of contaminated sites and assessment of excavated masses. Moreover, there are distinctions between on-site and off-site use of materials, especially contaminated soil. This is described in chapter 4.5.2.

Rock material in general is not considered a source or a sink for hazardous substances from pollution activities. This is due to the nature of rock minerals. In intact rock no absorption of hazardous substances occurs. However, under excavation or in subsequent processes, where rock is crushed to smaller particles, particle size may be critical if pollution is introduced via excavation processes. Naturally occurring pollution such as radioactivity or acid-forming shale may represent an issue.

Assessment of sites is initiated through the legal instruments that are in place in the countries, such as national act on soil contamination. However, there may be differences in whether this is done as a systematic and continuous process on national or local basis or as a case-by-case and therefore site-specific risk assessment. In **Denmark**, the Soil contamination act stipulates, that the Regions are responsible for the public efforts in the field of soil pollution. Thus, the Regions initiate the mapping of contaminated sites, advise on the use of contaminated sites and are responsible for any clean-up activities or other measures that ensure the reduction of risks of contaminated areas. Excavation activities or construction works at a site, triggers additional sampling and testing of excavated materials. In the same way, specific activities on a certain site, such as land use change or excavation or construction works, can trigger the need to investigate the contamination of land in **Finland** (Ministry of Environment, 2014). In **Sweden** contaminated land is assessed both as described in Denmark and Finland. Historic land use with industrial activities known to increase the risk for contamination of land (soil, ground- and surface water, buildings etc.) have been investigated and remediated by the regional authorities. Also new use of land, changed land use, building and demolition activities it is mandatory with a survey of site-specific conditions and communication with local or regional authorities.

The concept of polluting activities is used in all countries. Concept of polluting activities means, that there exists knowledge/expert experience on different types of industrial activities and the type of pollution this activity typically results in. All countries have created lists of those polluting activities, see e.g., "*Branchebeskrivelser*" hos *Regionernes Videncenter for Miljø og Ressourcer* in Denmark (VMR, 2021) and "*Grunnforurensning – bransjer og stoffer*", faktaark M-183, 2017 from the Norwegian EPA (2017) and Swedish national list with industrial activities and typical pollutions (updated 2020) (Naturvårdsverket, 2020c). In Finland, the SAMASE-project (Puolanne, et al. 1994) from the year 1994 lists these activities.

The process of site assessment varies from country to country and different approaches to risk assessment are used. This in turn has consequences on the types of environmental quality standards used in the assessment of contaminated sites. The nomenclature for these environmental quality standards varies in the Nordic countries, so do the numerical values for them and which contaminants may be included. Do we talk about threshold values, guidance values? The choice of sampling approach, analytical method prescribed, as well as statistical method for evaluation of analytical results have an influence when setting environmental quality standards. Links to relevant lists of environmental quality standards are provided in Appendix 2, but a detailed description and comparison of those aspects and the different numerical values cannot be given under the scope of this project.

Table 20 Framework for contaminated site management in the Nordic countries.

	Denmark	Sweden	Norway	Finland
Initiation of site assessment	Soil contamination act; Regions initiate site assessment. Site assessment, clean up etc. are run as a continuous process.	Regions initiate assessments of sites depending on historic use of land and in a nationwide coordinated program. //Planned activities with a risk for contaminated land is mandatory to investigate.	Regulation of Pollution chap. 2 § 2–4. Regulation of Buildings (TEK17) § 9–3.	Environmental Protection Act (527/2014), Decree on Assessment of Soil Contamination and Remediation Needs (214/2007).
Concept of polluting activities	Yes	Yes	Yes	Yes
List of polluting activities	Yes ¹	Yes ⁵	Yes	Yes
Steps in site assessment	Knowledge of past activities – suspicion of pollution triggers mapping at knowledge level 1 (V1). Documentation of contamination triggers mapping at knowledge level 2 (V2) More advanced site investigation can subsequently be used to assess the extend and risk of pollution, which might result in remediation/ clean-up of the site. Use of environmental quality standards in V2-mapping and more advanced site investigation	1. Identification of risks for contaminated land from previous and actual use 2. Identification of sources for contaminations 3. Determination of the level of contamination 4. Determination of transport mechanism for contaminants 5. Identification of exposure scenarios 6. Identification of objects to be protected 7. Risk assessment with site specific target values, limiting parameters for the assessment. Assessment of measures to protect the objects of concern	Knowledge of past activities triggers preliminary investigation (phase 1 study). Suspicion of pollution triggers assessment by soil sampling (phase 2). Site-specific risk assessment depending on contamination type.	1. Identification of the need for site- assessment based on site history and application of threshold and background values 2. Risk identification, including identification of contaminant sources, receptor, exposure and transport routes, development of initial conceptual site model 3. Risk determination, including assessment of exposure/transport routes based on sampling and site studies, application of reference values 4. Risk characterization, including uncertainty analysis and conclusion on risk acceptability. (Reinikainen, 2021). For more detailed information refer to Figure 12 in appendix 2, section 9.4
Approach for assessing contaminated sites	Focus on the protection of drinking water resources and the prevention of risks to human health in the use of contaminated areas.	Identification of risks, sources, transport paths, objects to protect and total risk assessed. Objects to protect include human health, the environment (ecosystems), and natural resources i.e. ground and surface waters.	Focus on risk to human health and environment and remediation of polluted soil according to planned use of the property and/or risk to recipients.	Site-specific assessment of risks to human health, ecosystems, and natural resources (e.g. ground and surface water) based on a conceptual site model (source-pathway-receptor linkage) (Reinikainen, 2021).

Environmental quality standards	Threshold values for contact risk (soil quality criterion and cut-off criterion; total content mg/kg, and evaporation criteria for volatile compounds; mg/m ³) and groundwater quality criteria for site-specific risk assessment for groundwater (µg/l) (Danish EPA, 2018) +70 substances/group of substances on the list of criteria.	Soil-quality standards including target values for toxicology, ecotoxicology and protection of ground and surface waters as sources for drinking water. The Swedish general target values is a list with 60+ substances/groups. Classification and risk assessment of toxicity and ecotoxicity is based on the European legislation for classification, labelling and packaging of chemicals (Regulation EC no 1272/2008) which applies to all chemical substances used in the EU.	Screening values set out in national legislation. Definition of polluted soil includes parameters such as acid forming rock and others with potential to pose a risk to the environment and limit values for 59 substances (mg/kg dry material).	In a Decree 214/2007 soil threshold values (applied as trigger values for site-specific assessment), and soil guideline values (mg/kg) (applied as tools to assess soil contamination and remediation need). The guideline values, however, are not legally binding decision benchmarks, i.e. the site-specific risk assessment is prioritized over the values. +50 substances or group of substances. In the national guidance document (Ministry of the Environment 2014) generic reference values (non-binding) given also for the other environmental media (groundwater, surface water and indoor air) as well as for the protection of human health (i.e. TDIs) (Reinikainen, 2021).
Inventory of contaminated sites	Yes, information is freely available online ² .	Yes, database available online for the regional sites ⁴ .	Yes, information is available for free online ³ .	Yes

¹ Regionernes Videncenter for Miljø og Ressourcer (2021),

² Danmarks Arealinformation, Danmarks Miljøportal (2021),

³ Norwegian EPA-database of Ground Pollution (Miljødirektoratet, 2021b) and Norwegian official property register (Se eien-dom, 2021),

⁴ Swedish regional database <http://www.ebhportal.se/Sv/Pages/default.aspx>,

⁵ Swedish national list with industrial activities and typical pollutions (updated 2020) (Naturvårdsverket, 2020c)

4.5.2. Main approaches and legal framework for risk assessment in application of naturally occurring materials

As described in the section above, there are differences in how risk assessment of soil contamination is carried out in the Nordic countries. This has influence on whether there is knowledge of possible contamination prior to excavation of soil or other naturally occurring materials. As described, there are also differences in the environmental quality standards or limit values used in risk assessment of soil pollution.

The following section delves into how the interplay between the regulation of excavated masses, soil pollution and limit values are, in order to be able to identify differences and similarities between the countries. This is not a comparison or evaluation of how the different countries look at risk and weigh risk and assess risk in relation to other environmental goals.

Our focus is to illustrate the framework and process for management and assessment of excavated materials in the four Nordic countries. In other words, which steps need to be taken by stakeholders, when materials are to be excavated and used either on-site or off-site?

In the following tables (Table 22 to Table 25) we have described this process and it

shows, to what extend and how risk assessment of naturally occurring materials is applied in the management of excavated materials:

- Can excavated soil or other naturally occurring material be used on site?
- What needs to be done if excavated materials are to be used on-site?
- What needs to be done in case of projects, that are situated in urban areas contra rural areas?
- How is this different in case of materials, that are to be use off-site?
- Which materials are covered, e.g., only soil or are rock masses covered as well?
- How do the requirements and approaches for unpolluted materials differ from polluted materials?
- Are requirements for risk assessment and limit values the same as in general risk assessment or are specific requirements and limit values applicable?

The information in the tables is based on our expert knowledge and the gathered information on the policy instruments and requirements for risk assessment in application of naturally occurring materials. The tables follow the same structure and layout, as shown below in Table 21. We distinguish between two situations:

- Yes, on-site use is possible - meaning the contractor has identified a use for the excavated material on-site. But what needs to be done now depending on whether the site is in an urban area contra rural area? And what needs to be done if no information on pollution level of the material is available, as compared to when the material is polluted or not polluted?
- No, off-site use needs to be arranged – meaning that there is no use for the excavated material on site. The contractor needs to identify a suitable project, where the material can be utilized. What needs to be done now depending on whether that project site is in an urban area contra rural area? And what needs to be done if no information on pollution level of the material is available, as compared to when the material is polluted or not polluted?

Table 21 Example to the reader

Do you have excavated soil or other naturally occurring material that can be used on site?		
YES, On-site use is possible	Is the site in an urban area?	NO Description of the necessary steps to be taken if the answer is NO.
		YES Description of the necessary steps to be taken if the answer is YES.
	Is the material polluted?	DO NOT KNOW Description of the necessary steps to be taken if there is no information on pollution levels.
		NO Description of the necessary steps to be taken if the material is not polluted.
NO, Off-site use needs to be arranged	Is the site in an urban area?	NO Description of the necessary steps to be taken if the answer is NO.
		YES Description of the necessary steps to be taken if the answer is YES.
	Is the material polluted?	DO NOT KNOW Description of the necessary steps to be taken if there is no information on pollution levels.
		NO Description of the necessary steps to be taken if the material is not polluted.
		YES Description of the necessary steps to be taken if the material is polluted.

As mentioned previously, rock material in general is not considered a source or a sink for hazardous substances from pollution activities. Because of that, rock material without fine grained particles to sample is usually not sampled and tested in **Sweden, Norway, and Finland** to determine content of pollution prior to excavation activities. The exception is when the rock itself may contain naturally occurring substances that might pose a risk of harmful effects when excavated. Moreover, facility owners and producers of rock material products have identified a lack in sampling and testing methods for rock materials and are thus lacking regarding site and material specific assessment (van Berlekom, 2021). For laboratory testing, decisions need for example to be taken on sampling strategy (e.g., use of composite samples), sample preparation (e.g. grain size fraction tested, potential pre-treatment steps like grinding prior to testing), type of chemical analysis method (digestion method) and also type of leaching test. The interpretation of the test results from laboratory testing is highly connected to the choices taken. In **Finland and Sweden**, the authorities may require, that content of sulphide and nitrogen is assessed, the latter to determine whether residues from explosive agents are present. However, that would be the case for excavated material and not prior to excavation. It is planned that threshold values for acid generation potential will be given in the upcoming Finnish regulation (Reinikainen, 2021).

In **Denmark**, soil or other naturally occurring materials, that are to be excavated in

urban areas need to be sampled and tested to determine, whether the soil is to be classified as unpolluted (category 1), slightly polluted (category 2) or polluted. This is done based on limit values, that are set for the classification, excavation, and removal of soil. Based on this information, management on-site or off-site can be arranged. In Denmark, urban areas are classified as slightly polluted. Once, excavated, slightly polluted soil can be utilized either based on a permit and/or notification. Polluted soil is typically classified by municipalities that also set requirements for management, such as the remediation or landfill of excavated soil. In the case of unpolluted soil, however, permits for the utilization are generally not required. Typically, projects simply must comply with current regulations for terrain regulation in local plans or for rural zones.

Recovery of soil will typically require a permit and in this context a site-specific risk assessment must often be prepared. However, risk assessment can be prepared at several levels from very simple assumptions and calculations based on total content, site specific information etc. to the preparation of major risk models and performance of leaching tests. Environmental quality standards, such as soil quality criteria, cut-off criteria and evaporation and groundwater criteria, and risk assessment tools such as the JAGG-model, that are applied in the general efforts on risk assessment of soil contamination are often used in this context. Environmental quality standards take into account sensitive uses such as housing, children's institutions and playgrounds, where children can come into direct contact with the soil (see Appendix 2 for more information).

As for Denmark, urban areas in **Sweden** are typically classified as slightly polluted and limit values for unpolluted, slightly polluted soil or polluted soil exist. Notification, sampling, analysis, and permits are necessary to utilise soil on-site or off-site. The contamination level in the excavated material is the limiting factor and determines to what extent a risk assessment must be carried out in that case. Environmental quality standards for *Sensitive use of land* and *Less sensitive use of land* are used to determine whether excavated materials can be used on site. In practise however, the same environmental quality standards are used to determine the possibility for off-site use of excavated materials. In case of off-site use of materials, excavated materials must match the classification of either *Sensitive use of land* or *Less sensitive use of land* at the receiving site.

An assessment of the quality of materials by means of sampling, analysing and comparison with condition classes is the starting point in **Norway**. Norway operates with 5 condition classes to define the level of pollution for soil. Those condition classes take into account sensitive land uses and subdivide soil in 5 levels of pollution, ranging from lesser polluted in e.g., class 1 to higher degrees of pollution, e.g., in class 5. In Norway, "slightly polluted soil" is not defined in legislation or by specific limit values, as is the case in Denmark. The term is still used for Norway in this report to make the comparison between countries manageable. Compliance with the condition classes determines, if excavated materials can fulfil the requirements for the intended use in case of on-site use. Guidelines on how to carry out risk assessments offer support for practitioners and help to evaluate compliance with condition classes. Off-site use requires an application and a site-specific risk

assessment. In our experience, the threshold for getting a permission to add new contamination to a new site, is higher than for leaving residual contamination at an already contaminated site behind.

In **Finland**, risk assessment of contaminated land masses is always case specific and carried out at the place of excavation. This involves sampling, analysis, and comparison to threshold values as a starting point. This determines whether risk to the environment is negligible. If concentrations are below threshold values, materials can be utilised without any further testing. However, if threshold values are exceeded, a site-specific assessment needs to be carried out, where lower and upper guideline values can be applied. The results of this assessment determine, how materials can be managed and whether a notification to authorities is necessary or not. A new regulation regarding the utilization of excavated soils is in preparation.

Table 22 Approaches and framework – Denmark. Which steps need to be taken by stakeholders when materials are to be excavated and used either on-site or off-site?

Do you have excavated soil or other naturally occurring material that can be used on site?		
YES, Onsite use is possible	Is the site in an urban area?	NO Rural areas are typically outside classified areas. Excavated soil in rural areas can be used on-site. In case of suspicion of pollution, the local municipality needs to be contacted.
		YES Urban zones are classified as slightly polluted area. Sampling and analysis of the excavated soil will determine the actual level of pollution.
	Is the material polluted?	DO NOT KNOW Is there information on possible contamination? Check assessment of knowledge level 1 (V1) and 2 (V2) and area-classification (see more information below). If there is time, take samples before excavation.
		NO Excavated soil can be used on-site. YES Slightly polluted soil may be used on site. Permit is required pursuant to §19 of the Environmental Protection Act. Polluted soil is categorised by municipalities. Polluted soil is managed by treatment, in construction works or landfilling. This may be in designated facilities requiring environmental permits such as land reclamation projects. In this context a site-specific risk assessment must often be prepared.
NO, Off-site use needs to be arranged	Is the site in an urban area?	NO If off-site use is in a rural area, excavated soil is not notifiable.
		YES Urban zones are classified as slightly polluted area. Excavation and removal of soil needs to be notified to the municipality
	Is the material polluted?	DO NOT KNOW If there is time, take samples before excavation.
		NO Excavated material may be used in other projects. YES Depending on the nature of the project, a permit may be required. This in turn may require a site-specific risk assessment to determine what type of materials and what level of pollution are acceptable at the relevant site.

Table 23 Approaches and framework – Sweden. Which steps need to be taken by stakeholders when materials are to be excavated and used either on-site or off-site?

Do you have excavated soil or other naturally occurring material that can be used on site?		
YES, Onsite use is possible	Is the site in an urban area?	NO Rural areas are typically outside classified areas. Excavated soil in rural areas can be used on-site. In case of suspicion of pollution, the local municipality needs to be notified.
		YES Urban areas are typically classified as slightly polluted area with levels sensitive and less sensitive land use. Soil from the same levels of land use can normally be used. Notification, sampling, analysis, and permit application is mandatory depending on the initial risk assessment and the historic land use.
	Is the material polluted?	DO NOT KNOW Basic risk assessment is mandatory. Control of historic land use and information in database and local archive is made. Notification is made to the local municipality. Phase 2 investigation is made if the risk assessment results in a risk higher than sensitive land use. That would mean sampling, analysis and evaluation with new classification.
		NO Excavated soil can be used on-site but with consideration to the level of land use for the area i.e. non-polluted soil equals level of pollution lower than sensitive land use. YES The level of contaminations in the material is the limiting factor. A site-specific risk assessment can be made for use of contamination levels slightly above less sensitive land use. Permit according to the Environmental act is mandatory with a risk assessment and classification based on sampling, analysis, and evaluation against the target values for contaminated land. In case of the risk being over the target value limits and a denied permit for land use then the soil is classified as waste. Remediation can be made in-situ in some cases or by transport to special facilities for the purpose. In case of high level of pollution and classification as hazardous waste it is mandatory to transport the masses to an approved facility for hazardous waste.
NO, Off-site use needs to be arranged	Is the site in an urban area?	NO In general soil removed from site is considered as waste. Classification of the soil must be made. The level of contamination assessed if a risk is identified. The area to receive the masses must regardless of origin of the masses have its area classification (within detailed planning area) matching with the masses. Permit application or notification to local municipality must be made according to the Environmental code if risk of pollution has been identified.
		YES Same as above.
	Is the material polluted?	DO NOT KNOW In general soil removed from site is considered as waste. Basic risk assessment is mandatory. Control of historic land use and information in database and local archive is made. Notification is made to the local municipality. Phase 2 investigation is made if the risk assessment results in a risk higher than sensitive land use.
		NO In general soil removed from site is considered as waste. Excavated soil can be used off-site after notification and approval by the local municipality. Consideration to the level of land use for the area i.e. non-polluted soil equals level of pollution lower than sensitive land use. YES In general soil removed from site is considered as waste. The level of contaminations in the material is the limiting factor. A site-specific risk assessment can be made for use of contamination levels slightly above less sensitive land use. Permit according to the Environmental act is mandatory with a risk assessment and classification based on sampling, analysis, and evaluation against the target values for contaminated land. In case of the risk being over the target value limits and a denied permit for land use then the soil is classified as waste. Remediation can be made in-situ in some cases or by transport to special facilities for the purpose. In case of high level of pollution and classification as hazardous waste it is mandatory to transport the masses to an approved facility for hazardous waste.

Table 24 Approaches and framework – Norway. Which steps need to be taken by stakeholders when materials are to be excavated and used either on-site or off-site?

Do you have excavated soil or other naturally occurring material that can be used on site?		
YES, Onsite use is possible	Is the site in an urban area?	NO The use must also be in compliance with regulations in the zoning plan and other restrictions set by the Planning and Building Authority, environmental goals and principles given in the Water Management Regulation (implementation of EU Water Directive) and the Nature Diversity Act.
		YES The use must also be in compliance with regulations in the zoning plan and other restrictions set by the Planning and Building Authority, environmental goals and principles given in the Water Management Regulation (implementation of EU Water Directive) and the Nature Diversity Act.
	Is the material polluted?	DO NOT KNOW A desktop study (phase 1 study) and assessment by sampling (phase 2 study) of possible pollution are carried out according to requirement in Regulation of Pollution chap. 2 § 2-4, guideline for health-based classes for polluted soil (TA-2553/2009) and Norwegian Standard 10381-5. Results are evaluated according to definition of polluted soil in Regulation of Pollution § 2-3 and limit values in chap. 2, appendix I.
		NO Excavated soil can be used on-site if the technical properties of the material is suitable for the application. YES Classification of total concentration (mg/kg dry material) according to guideline for health-based classes for polluted soil (TA-2553/2009). Can be re-used on-site according to the regulation of the property and acceptable pollution class in guideline TA-2553/2009. And if technical properties are OK.
NO, Off-site use needs to be arranged	Is the site in an urban area?	NO The application must be in compliance with regulations in the zoning plan and other restrictions set by the Planning and Building Authority, environmental goals and principles given in the Water Management Regulation (implementation of EU Water Directive), the Nature Diversity Act and Norwegian EPA Fact Sheet M-1243 for re-use of excavated unpolluted material.
		YES The application must be in compliance with regulations in the zoning plan and other restrictions set by the Planning and Building Authority, environmental goals and principles given in the Water Management Regulation (implementation of EU Water Directive), the Nature Diversity Act and Norwegian EPA Fact Sheet M-1243 for re-use of excavated unpolluted material.
	Is the material polluted?	DO NOT KNOW A desktop study (phase 1 study) and assessment by sampling (phase 2 study) of possible pollution are carried out according to requirement in Regulation of Pollution chap. 2 § 2-4, guideline for health-based classes for polluted soil (TA-2553/2009) and Norwegian Standard 10381-5. Results are evaluated according to definition of polluted soil in Regulation of Pollution § 2-3 and limit values in chap. 2, appendix I.
		NO Excavated soil can be re-used off-site according to guidelines in Norwegian EPA fact sheet M-1243 for re-use of excavated unpolluted materials. The use must also be in compliance with regulations in the zoning plan and other restrictions set by the Planning and Building Authority, environmental goals and principles given in the Water Management Regulation (implementation of EU Water Directive), the Nature Diversity Act. YES Surplus soil must be transported to legal waste disposal/treatment facility for polluted soil.

Table 25 Approaches and framework – Finland. Which steps need to be taken by stakeholders when materials are to be excavated and used either on-site or off-site?

Do you have excavated soil or other naturally occurring material that can be used on site?		
YES, Onsite use is possible	Is the site in an urban area?	NO The use must be in compliance with regulations laid down in the Land Use and Building Act (132/1999).
		YES The use must be in compliance with regulations laid down in the Land Use and Building Act (132/1999).
	Is the material polluted?	DO NOT KNOW Risk assessment should be performed prior to excavation, as it is not applied to excavated masses. It is to be performed based on the provisions laid down in the Environmental Protection Act (527/2014) and Decree on Assessment of Soil Contamination and Remediation Needs (214/2007). It is to be applied at adequate level of detail depending e.g. on the site in question and the targets of the risk assessment (Reinikainen & Sorvari 2016).
		NO Excavated soil can be used on-site if the technical properties of the material are suitable for the application.
NO, Off-site use needs to be arranged	Is the site in an urban area?	NO The use must be in compliance with regulations laid down in the Land Use and Building Act (132/1999).
		YES The use must be in compliance with regulations laid down in the Land Use and Building Act (132/1999).
	Is the material polluted?	DO NOT KNOW Risk assessment should be performed prior to excavation, as it is not applied to excavated masses. It is to be performed based on the provisions laid down in the Environmental Protection Act (527/2014) and Decree on Assessment of Soil Contamination and Remediation Needs (214/2007). It is to be applied at adequate level of detail depending e.g. on the site in question and the targets of the risk assessment (Reinikainen & Sorvari 2016).
		NO Excavated soil can be used off-site if the technical properties of the material are suitable for the application.
		YES According to the Environmental Protection Act (527/2014) an environmental permit is needed for activities posing a risk of environmental pollution. The criteria of the receiving site must always be met and demonstrated separately. If the excavated soil is classified as contaminated, the criteria of the receiving site determine what needs to be separately investigated (i.e. what risks need to be assessed).

5. Barriers and challenges

The previous sections show that the regulation and management of naturally occurring materials is subject to a complex set of regulations in the Nordic countries. They also show that there is potential for optimized resource utilization of the materials. However, there are several common barriers and challenges in the Nordic countries that prevent this in practice. If naturally occurring materials are to be managed in a more efficient way, both the regulatory and practical challenges must be solved.

Many stakeholders are involved in the management of naturally occurring materials, from project owners and contractors to transport companies, waste treatment or disposal facilities, and authorities at national, regional or local level. Therefore, there will of course be a difference between what is perceived as a barrier or challenge and by whom.



Figure 8 Many stakeholders are involved in the relocation and management of excavated materials

Illustration: Rogaland fylkeskommune (2017)

Based on our knowledge of barriers and challenges in the management of naturally occurring materials and additional information, that was gathered during the project, we provide an overview of the most important common barriers and challenges that we have identified with respect to regulatory barriers and challenges. For additional and country specific information, please refer to appendix 1.

Regulatory barriers and challenges

As the analysis and evaluation show, existing legislation is not a direct barrier that prevents optimal utilization of resources. However, there are several untapped opportunities in regulation as well as problem areas that appear as barriers in practise. These problem areas are lack of specific requirements, complex set of rules, classification of waste, requirements for waste statistics. Regardless, the existing regulation is rather perceived as not to promote a better utilization of the materials, which in isolation can be perceived as a barrier.

Apart from soil and soil contamination, which are regulated to varying degrees in the Nordic countries, there is no specific regulation of naturally occurring materials. Although there is generally a focus on better utilization of naturally occurring materials, which is expressed, for example, through local or regional strategies and initiatives, there is no objective or even specific requirements for better utilization of these resources in policy instruments.

Management of naturally occurring materials is subject to a complex set of regulations, which presupposes in-depth knowledge of authorities, contractors, and other involved stakeholders regarding requirements for permits, environmental quality standards and implementation of risk assessment of materials in practise.

The classification of naturally occurring materials as waste or non-waste is of great importance for the management of the materials, as classification as waste automatically will mean that a material is subject to waste legislation. That in turn has impact on requirements with regards to environmental approvals, permits, and consequently costs, time for approval, charges and taxes and possibilities of waste management.

Furthermore, management of naturally occurring materials is primarily based on classification of waste or non-waste and does only to a smaller degree consider the technical and geotechnical properties of the materials.

In general, the existing waste statistics are a poor tool to provide a detailed overview of amounts of naturally occurring materials and their management in practise. This does not represent a direct barrier. However, it will currently not be possible to set material specific recycling criteria if the status of management and thus actual potentials for better utilization of naturally occurring materials are not fully known.

Barriers and challenges for management of naturally occurring materials in practise

Efficient utilisation of naturally occurring materials in the Nordic countries faces a wide range of challenges in practise and from different angles. It is the interplay of different factors that represents challenges or actual barriers for the efficient management of naturally occurring materials. This includes aspects such as planning, preliminary investigations, lack of requirements in regulation and/or tender documents, lack of information and coordination, classification as waste/non-waste, management according to pollution level and costs.

Efficient management of materials presupposes good planning of building and construction work. It is in the planning phase of a project that one can influence the design of it. This may mean that one can consider how excavated materials can be

utilized on site, or how one can reduce them through custom design of the project. This only happens to a rather limited extent in practice.

It is also at this point that, based on preliminary investigations or feasibility studies, one can estimate quantities and qualities of excavated materials in order to investigate possibilities for on-site and off-site use. Supply and demand of excavated materials rarely coincide, and if they do not match in terms of time, amounts, quality, and location, this gives challenges in practice. If a contractor cannot find suitable use for materials on-site or off-site, materials may be regarded as waste. If storage time becomes unreasonable long, this will increase costs and may even exceed legal requirements for storage, which in turn may require the disposal of materials.

Sweden – a market initiative on Market places and platforms

Common digital marketplaces at which buyers and sellers can meet to exchange materials is not common practice in the sector, even though individual actors market their materials through their individual sales channels. There have been and are initiatives ongoing for development of marketing strategies concerning material handling. According to NCC Industry there are obstacles regarding competition with virgin materials (van Berlekom, 2021). Secondary raw materials have a need for quality assurance with sampling, testing, evaluation, and classification, other than that for primary raw materials. This and need for processing of secondary raw material increases the cost and market price for secondary raw material compared to primary materials.

Infrastructure projects with tunnels vs quarries

A crushing plant is being built in a place where a suitable raw material has been found – a deposit – with the right properties for stone products. There are large, homogeneous masses of the same type of geology, which makes it possible to plan and operate a quarry for a long time. Masses are taken out according to the needs of the market. The quarry is located in reasonable proximity to the market.

However, in a road or railway project, road lines and tunnels over a long stretch have normally very variable geology. This requires detailed planning in order to utilize the geological resources. In this type of projects, the crushing plant is often far from built-up areas, and the plant must be completed in the shortest possible time. This makes it challenging to find areas of application for surplus materials.

Large projects in rural areas can be challenged by the fact that there is a long way to transport materials to the next project if on-site recycling is not possible. On the other hand, large projects may have better conditions for finding suitable solutions themselves. This could be for example, terrain regulation in the project or noise barriers if these are to be constructed. Smaller projects are often challenged by the fact that there are smaller amounts of materials to be managed, which can be a problem. Moreover, in excavation projects, such as in excavation of foundations it may be even more challenging to find suitable use of material on site. Regardless of the project, the type of material and its technical quality will of course have an impact on the opportunities for recycling that present themselves. The choice of excavation technique will in turn also have an influence on the technical quality and opportunities for recycling (see also the box below "Rock blasting or tunnel boring machines?").

Specific requirements in the legislation or in the tender materials would support that the contractors or other relevant stakeholders put more focus on planning and feasibility studies, as this will be a necessary precondition for them to be able to meet the requirements. However, this is lacking in practice.

When, at the same time, there typically is a lack of information and coordination between projects in terms of available quantities, suitable projects, that could utilize the materials, permits to be applied for etc., materials are typically managed in the simplest and most cost-efficient way. In some instances, disposal at local landfilling facilities is often the easiest and cheapest solution, even for unpolluted materials.

Management of materials is done based on classification as waste, based on pollution level and costs. This entails significant longer time for decisions and increased costs and more administration for companies handling these masses. The technical quality of the naturally occurring materials is only rarely taken into account.

Rock blasting or tunnel boring machines? In the Norwegian project “Kortreist stein” (short-travelled rock), several reports have been made. The text below is a synthesis of some relevant points with regards to the choice of excavation technique.

Before deciding whether to use traditional drilling and blasting or a tunnel boring machine, the geology of the area should be investigated, and what kind of utilization which might be possible. Should the stone be used as aggregate in concrete, asphalt, load bearing or reinforcement layers in roads, or as backfill materials? Does the stone have a quality that is good enough? High content of mica or sulphur is undesirable. What grain distribution requirements are set for the masses?

TBM materials have a different grain distribution than drill and blast. The sludge content is 10–15% for TBM, while drill and blast gives much lower values. There are generally much more fines in TBM materials, and too little of the coarse fraction, which means that sieving and sorting may be necessary, possibly the addition of chemicals. A lot of fines and water from tunnel boring also increase the need for cement if the materials are to be used for concrete production. This gives a higher environmental impact of the concrete and gives poorer frost properties for the concrete. There are standards for requirements for masses to be used for concrete, asphalt, or base layers in roads. In general, it can be said that the highest requirements are set for concrete purposes. Then asphalt, ballast crushed stone, and bearing / reinforcement layers come into play, see Figure 9 (Rise et al, 2019 and Alnæs et al, 2019).

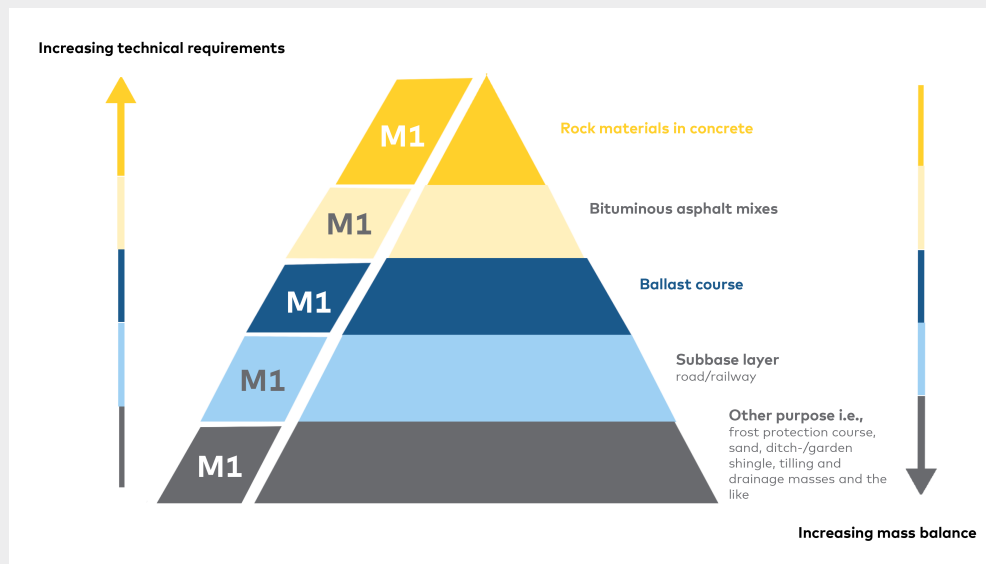


Figure 9 Different setups of crushing equipment produces different end products.

A general perception in the C&D industry is that TBM materials (also rock) in general have a lower quality for re-use purposes, which historically has led to TBM materials being deposited in landfills in association with the infrastructure projects. TBM materials has also shown the need for processing before it may be used as additives in concrete structures.

6. Recommendations

Based on our knowledge and the information gathered during the project, such as information from relevant projects and studies as presented in chapter 2, we have formulated several recommendations. The recommendations are formulated for two groups of stakeholders:

- **Authorities:** Recommendations for authorities (see Table 26) focus on policy instruments and guidance that may be beneficial for the efficient management of relevant materials, such as the need to develop new future applicable instruments, or the need to adapt existing policy instruments, respectively. Authorities refers to authorities at national, regional and local level involved or responsible for the management of naturally occurring materials.
- **Operators:** Recommendations for operators (see Table 27) focus on best practise identified in relevant studies at Nordic level and guidance for the relevant and suitable use of materials. Operator in this context refers to companies involved in construction activities, where naturally occurring materials are excavated.

Table 26 Recommendations for authorities.

Recommendation for authorities	Further explanation
Set legal requirements for utilisation of naturally occurring materials	National or local requirements for the utilisation of materials will create an incentive to improve the management of naturally occurring materials. Legal requirements will create a stronger incentive as compared to strategic incentives but may limit stakeholders in the most efficient management in a given project.
Set goals in strategies for the management of naturally occurring materials	There is increasing focus on the reduction of CO ₂ -emission and efficient resource use especially from the construction sector. The examples in e.g., section 2 have demonstrated that strategies and guidelines are already in place to support the industry. Defining goals for better utilization of resources in strategies, whether local, regional, or national, can increase focus on the topic and support the industry in implementing suitable solutions.
Use economic instruments to provide incentives	Exemption from charges or landfill taxes is a barrier for optimised management of naturally occurring materials. Economic instruments have to be used as to create an incentive.
Use lifecycle perspective to evaluate benefits of utilisation	Authorities should use a lifecycle perspective to a greater extent to evaluate the benefits of utilisation of naturally occurring materials. Lifecycle perspective should supplement the assessment of risk for environment and health, that may be associated with the utilisation.
Set requirements in tender documents	To the extent that authorities, such as municipalities or the state are project owner, specific requirements in procurements for utilisation of naturally occurring materials will create a strong incentive to improve management of naturally occurring materials. Requirements for naturally occurring materials in public procurement could encourage optimised management.
Create incentives to address planning and logistics in planning stages of projects	Incentives can be created via legal requirements, such as requirements of preliminary investigations of quality and quantities to be expected in construction projects, similarly to requirements for pre-demolition audits and waste notifications.
Provide guidance in classification of masses and in risk assessments	This presupposes that an effort is made to clarify the rules via guidance material and similar tools and / or to support the industry through targeted guidance efforts. Guidance on classification of waste/non-waste is needed as well as guidance on risk assessment and management.

Improve knowledge on naturally occurring materials	Improved knowledge on different types of naturally occurring materials, their properties, and technical qualities as well as status for management is necessary to support the setting of material specific recycling criteria. Improving national statistics would require substantial work, as this would require the adaptation of existing legislation, but will probably still not provide a complete overview of non-waste materials
Establish digital solutions for the notification and permit process	Digital solutions can ease notification and permit processes. If establish at national level, they can contribute to a more uniform way of reporting. This in turn may help both industry and authorities to coordinate at national scale and may support concepts as marketplaces.
Establish digital solutions with forecast of amounts	Establish digital solutions at local, regional, or national level, that can utilise data from projections and forecasts on expected amounts based on planning information from relevant projects.
Marketplaces and platforms	Supply and demand of materials rarely match. Marketplaces and platforms can support industry in matching materials and projects. However, information on materials, location, quality, risks need to be available in a uniform. Ideally, it must be independent systems to ensure the credibility of the data.

Table 27 Recommendations for operators.

Recommendations for operators	Further explanation
Ensure sufficient time for planning	Planning is an effective tool. If time and project allow for it, consider possibilities to minimise the amount of excavated material. E.g. in road construction, if only the tracing of the road project is defined but not the level, this may open for possibilities of minimizing quantities through planning.
Ensure sufficient time for preliminary investigations	Preliminary investigations can ensure, that sufficient information can be generated to estimate expected amounts of material, possible level of pollution, technical quality etc. Because, once the material has been excavated it must be decided how to manage it, in order to minimise costs.
Coordinate with other stakeholders and keep your own projects in mind	In order to match supply and demand of masses, it is important to coordinate with other relevant stakeholders to get information on relevant projects that may have supply or demand of material. Appointing a coordinator for this work may enhance possibilities for utilisation.
Marketplaces and platforms	Use marketplaces to support you in identifying supply with relevant materials and make your supply visible to others.//For larger companies, internal platforms may create this overview based on information from planning exercises. This may help to identify supply and demands in the company's own project portfolio.
Keep a geological lab on site	One of the recommendations from the "Short-travelled stone" project is that there should be a geological lab on the construction site. This makes it much easier to keep control of the stone quality at all times. The masses can be roughly sorted and distributed.
Have areas for sorting and intermediate storage of different stone qualities	Another recommendation from this project is to have areas for sorting and intermediate storage of different stone qualities. This ensures a greater degree of high-value reuse. Studies were also made on the crushing concept for various purposes (Onnela, 2019). The same crushers could be set up in different ways, producing different types of end product.

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Appendix 1

Barriers and challenges in the management of naturally occurring materials

In the following section barriers and challenges in the management of naturally occurring materials are listed. The information gathered is based on expert knowledge in this field and supplemented with information from relevant interview and studies. The information is presented for the Nordic countries.

Denmark

Based on our knowledge, relevant references as well as interviews carried out during the project, we have identified the following barriers and challenges to increase the utilization of natural occurring masses in Denmark:

- Lack of requirements in tenders.
- Lack of preliminary investigations, initial knowledge of quantities and grades make it difficult to make demands on nuanced handling of materials.
- Management of materials in practice depends on procurement requirements and who completes the task – the right mindset.
- Management of materials depends on waste versus non-waste status.
- The management of materials depends on the level of pollution.
- Materials, such as muck, that are not defined or described in detail in the legislation, in regulations, with EAK code, etc. are difficult to place in the regulatory framework. It complicates their handling.
- Transport distances are a challenge.
- Planning/time/logistics is a challenge.

In practice management is controlled through the level of pollution and not through soil type. In addition, the possibility of handling the materials – if you have a concrete receiver for a material, especially unpolluted materials, you make more effort to sort/take it from.

Barriers and challenges pointed out in interview with Metroselskabet I/S (Bech et al. 2021):

In general, the organization of waste management as it is today constituting a barrier to better utilization of waste. The organization has taken place on the basis of legal requirements, contract requirements, space and planning requirements and finances / incentives. The very varying amounts of waste in the various phases of construction can constitute a barrier to profitable recycling. Ensuring proper storage of waste so that it does not deteriorate also constitutes a barrier to recycling. Lack of information and awareness combined with language and culture among the employees of many different nationalities constitute a barrier to waste sorting. Pollution of the soil and documentation of cleanliness can constitute a barrier to

recycling, especially internally in the project.

The content of flint and other impurities in the muck, as well as transport distances and other practical limitations, such as the take-off structure, constitute a barrier to recycling.

Sweden

Identified barriers and challenges to increase the utilization of natural occurring masses in Sweden are based on previous studies as well as the knowledge and expertise from the authors. The identified barriers and challenges identified are:

- **Surplus masses are generally considered as waste**

Generated surplus masses which are not used at the site of excavation, are today generally considered as waste. As a waste, receiving facilities must apply for environmental permits in the same way as conventional waste facilities such as landfills. This entails significant longer time for decisions, increased costs and more administration for companies handling these masses (Expertgruppen för Cirkulär anläggningsindustri, 2020).

- **Limited storage opportunities**

In large infrastructure projects, large amounts of masses are generated under a rather short period of time which can't be used on the same construction site as being generated. In addition, it is difficult to find a demand for generated amounts within a reasonable time after they have been generated. This requires the opportunity to be able to store masses for a longer period of time, during which it is possible to find use for masses in other construction projects. Today there are limited opportunities in terms of space to locally store masses. From a legal point of view, there are today also limitations regarding time of storage where masses today are only allowed to be stored for maximum 3 years if they are intended to be used again. If intended to be disposed of through landfilling masses are allowed to be stored for a maximum of one year. The relatively short time frames for storing masses are identified as a barrier for a more circular handling of masses by Rosén et.al. (Rosén, L., Norrman, J., Söderqvist, T et.al, 2020).

- **Exemption from and deduction of the landfill tax**

The landfill tax in Sweden today is more than 500 SEK/tonne of waste. However, landfills only receiving certain types of waste such as soils, gravel, rocks, rock debris etc. don't need to pay any landfill tax according to legislation (1999: 673) on tax on waste. In addition, landfills can deduct the entire landfill tax when received waste such as soils and excavation masses are used for construction purposes on landfills. This makes landfilling as well as using waste for construction and coverage purposes on landfills rather cost effective and financially competitive compared to different treatment options for masses which hamper material recycling of masses. The consequence of this barrier can be seen in the national waste statistics where significant amounts of soils and excavation masses are managed by landfilling and construction purposes on landfills (Naturvårdsverket, 2020a).

- **Low gate fees for using masses as construction materials on landfills**

As mentioned, there is a great demand for masses using them for construction and coverage purposes on landfills. This demand in combination with being able to deduct the landfill tax according to the bullet point above has resulted in very low gate fees making alternative recycling techniques difficult to compete financially.

- **Low and unclear requirements for pre-treatment before landfilling**

According to the Swedish waste legislation (2001:512), only waste which has been subject to prior treatment is allowed to be landfilled. However, today it is unclear what kind of treatment and to what extent is justified according to Rosén et.al. (Rosén, L., Norrman, J., Söderqvist, T et.al, 2020). The Swedish Environmental Protection Agency's recommendations (Naturvårdsverket, 2004) state that source sorting is sometimes seen as sufficient. This makes landfilling of non- treated masses generated at the construction site convenient and rather cost efficient compared to recovery options, which is reflected in the Swedish waste statistics (Naturvårdsverket, 2020a).

- **Significant transportation costs**

The low value of secondary masses must cover the costs related to logistics to be financially viable which also is considered as a barrier for the sector.

- **Valorisation of rock masses**

Valorisation of the material generated during infrastructural works is always a challenge. One such barrier is who is responsible for the valorisation, including material and, more so, the final product properties. Sampling of rock material for laboratory analyses can be made in several different ways and it significantly influences the evaluation of quality and properties of the final aggregate product. Sampling by drilling, which in some cases, is the only possibility will yield better laboratory test results on the critical mechanical properties compared to blasted or handpicked samples.

When a road construction is planned, with or without a tunnel through some crystalline rock, the contractor calculates the value of the material to be blasted, excavated etc and take this into account. If the Swedish Transport Administration knows the value it can be included in their calculations and considered when evaluating the different tenders. However, how is it to be taken into account is open for discussion? The value of the material also depends on the skills of the contractors (or subcontractors) to turn the material into a usable aggregate. The quality of the final product is therefore depending on a lot of different variables very difficult to include in a procurement. Construction works in a larger city also means that the extracted masses most likely have to be transported to another place for processing and storing until use. In a country road construction, the masses can often be crushed and used directly as part of the construction. The better quality, the higher up in the construction. In a dense city there is mostly a problem with storage space and space for processing the material/masses.

In addition, the outcome during an actual tunnelling operation depends on the equipment/technique used. The most commonly used technique is to use

explosives. The knowledge about the quality of these masses is much better compared to masses extracted by mechanical techniques such as with the Tunnel Bore Machine (TMB) where the resulting particles are extremely flaky compared to standard aggregates which is quite cubic/rounded.

Norway

Previous studies and regional and local authorities have identified several barriers and challenges in the management of materials and enhance re-use and recycling. Some of the barriers are based on the experience of the stakeholders and interview partners. See references in chapter 2.

The main barrier appears to be the current organization and regulation of waste management in Norway, under the implementation of the EU Waste Framework Directive.

Excess material from C&D activities, meaning material that is not sent to recovery or recycling, is defined as waste which in general requires application and permits from the authorities in order to utilize the materials (e.g. waste) outside legal waste plants or landfills. The national regulations and policies are presented in 9.3

The main barriers and challenges identified are as follows:

- Unclear legislation and several authorities across sectors. Risk of long case consideration by the authorities and/or rejection of applications for re-use unpolluted and/or polluted materials.
- Lack of (legitimate and suitable) areas to temporarily store, handle, sort and/or process masses in proximity to where the masses are generated.
- Restrictions on the time period materials can be stored before a permit from the authorities is required.
- Insufficient information on the amount and quality of masses that will be generated in the region makes it difficult for authorities to identify the need for management and guidelines in their region or municipality.
- Insufficient preliminary studies and assessments of the ground in projects in order to assess the quality and amounts that can be re-used.
- Supply and demand need to coincide in reasonable space and time.
- Lack of coordination between projects.
- Low demand for excess material from projects. In some areas of Norway, the price for new building materials is lower than cost to use excavated masses.
- Lack of incentives and requirements of re-use/recycling of materials by developers.
- Naturally high background levels of some substances and/or types of masses (e.g. some types of shale) pose a health or environmental risk if deposited elsewhere.
- When re-cycling and/or processing gives a higher transport- and/or energy cost.
- Quality of masses must meet the technical standards for the application.
- Dredging spoils must be de-watered (costly) before transport and application.
- Quality of dredging soils may not meet the technical standard of the application.

It should be noted that TBM masses (also rock) in general have a lower quality for re-use purposes, which historically has led to TBM masses being deposited in landfills in association with the infrastructure projects. TBM masses has also shown the need

for processing before it may be used as additives in concrete structures.

Finland

There are several barriers and challenges hindering the efficient management and utilization of surplus landmasses in Finland. Some of the main barriers and challenges are listed below:

- Surplus masses in Finland are typically mud, clay and silt, whose utilisation is difficult. In addition, the utilization of acid sulphate soils is demanding.
- No comprehensive and uniform information available on the quantity and quality of the masses generated and needed on construction sites (Huhtinen et al. 2018).
- Construction activities are increasingly located in areas whose soil types are either challenging to utilize or contaminants are present. The information obtained not until during the construction planning phase comes too late from the point of management of these masses. (Laine-Ylijoki et al. 2020)
- Information important for the management of surplus masses, e.g. regarding to soil type, technical properties, and behaviour of material on its planned application, is not available, nor operations models do exist (Laine-Ylijoki et al. 2020).
- If utilization of masses requires significant treatment, such as stabilization, life-cycle emissions may be significant and targets for resource efficiency are not met (Laine-Ylijoki et al. 2020).
- Supply and demand need to coincide in reasonable time, intermediate storage increases costs (Koivuniemi 2013).
- Transport costs and emissions generated. If transport distances are long, resource efficiency cannot be achieved. In addition, the lack of intermediate storage areas located in proximity to construction sites increase the distances of transport. (Huhtinen et al. 2018)
- Suboptimal use of surplus masses. Contractors may optimise the use of generated masses at construction sites only from the point of view of their own operations. Individual operators often do not have the possibility to use the excavated masses generated in their sites in a way that is optimal for the overall management. E.g., if large quantity of quarry material is produced and cannot be processed into crushed rock, it may be used in places where poorer quality masses could be used. As a result, poorer quality materials have to be landfilled in soil landfills due to lack of demand. (Huhtinen et al. 2018)
- Long lasting, resource-intensive and complicated permit and planning processes form a challenge for the utilisation and deposition of surplus landmasses. For example, a local detailed plan, environmental impact assessment, and several environmental etc. permits are required for disposal sites and treatment activities. Decision on a licence application may take several complaining rounds and the process for opening a new area may last around five years from the beginning of the permitting process. (Vaara 2011, Huhtinen et al. 2018)
- When assessing the waste status (i.e. is material considered as waste or not) of the excavated landmass, Section 5 in the Waste Act is applied. One of the criteria to be met is that the further use of masses needs to be secure, i.e. the material is directly delivered to the utilization site and it is not stored for long. This practice may limit the utilisation of excavated masses. For example, if it has not been possible to identify a secure further use for excavated material

generated, it has been identified as waste. The existence of a market demand for the excavated material is not sufficient for a secure further use; the intended use must be known at the beginning of the storage of the excavated material. If the excavated material is classified as waste, an environmental permit is required for its intermediate storage. Permit process is resource-intensive and time-consuming. Therefore, usable material may have ended up in landfill instead of being utilised. (Huhtinen et al. 2018)

- Risk assessment regarding to contaminated landmasses is always case specific and concerns the risk at the place of excavation or formation, not at the utilisation site. Therefore, environmental risks concerning the utilization need to be always assessed separately. In other words, when soil is excavated, the criteria of the receiving site must always be met and demonstrated separately. If the soil is classified as contaminated, the criteria of the receiving site determine what needs to be separately investigated (i.e. what risks need to be assessed). Generally, the utilisation of excavated contaminated soils is currently minor even in landfills, as they are exempted from the landfill tax. (Laine-Ylijoki et al. 2020)

Appendix 2

Policy instruments for the management of relevant wastes and materials in the 4 Nordic countries

A2.1 Danish policy instruments and strategies

As described in the previous chapter, the handling of naturally occurring materials in Denmark is mainly limited to excavated soil. The management of soil is subject to different sets of rules:

- Act on Soil contamination (Jordforureningsloven)
- Statutory order on notification and documentation in connection with the removal of soil (Jordflytningsbekendtgørelsen)
- Statutory order on the definition of slightly contaminated soil (Bekendtgørelse om definition af lettere forurenede jord)
- Statutory order on the use of residual waste, soil and sorted construction and demolition waste (Restproduktbekendtgørelse)
- The Environmental Protection Act (Miljøbeskyttelsesloven)
- Planning act (Planloven)
- Environmental Impact assessment (EIA) act (Miljøvurderingsloven)
- Information to the municipalities about a new land transfer order. (Orientering til kommunerne om ny jordflytningsbekendtgørelse) (Danish EPA, 2007)

A2.1.1 Rules regarding classification, excavation and removal of soil

Act on Soil Contamination

The regions are responsible for public efforts in the field of soil pollution. The regions map contaminated areas, advise on the use of contaminated areas and are responsible for any clean-up or other measures aimed at reducing the risk of contaminated areas. Other tasks in the field of soil pollution are handled by the municipalities, which classify areas with slightly contaminated soil, issue permits for building and construction work on mapped areas. Pursuant to the Act on soil contamination, rules are issued on the notification in connection with excavation and removal of soil, regulations on notifications schemes are issued by municipalities and rules on the recycling and use of soil for specific purposes, including rules on criteria and limit values.

Regions of Denmark

The five Regions of Denmark (Nordjylland, Midtjylland, Syddanmark, Sjælland, Hovedstaden) are created as administrative entities at level above the municipalities and below the central government. The Regions main responsibilities are healthcare, public transport, environmental planning, soil pollution management and coordination of secondary education.

Mapping of soil contamination and area classification

All contaminated areas must be mapped as a result of the Act on soil contamination. However, areas that are only slightly contaminated are exempt from this requirement. Slightly contaminated soil is often the result of diffuse pollution, that has arisen through long-term diffuse pollution from several sources of pollution. Mapping takes place at 2 levels – knowledge level 1 and knowledge level 2, respectively:

- An area can be mapped at knowledge level 1 (V1) if there is knowledge of activities that may have caused pollution on the area.
- An area can be mapped at knowledge level 2 (V2) if there is documentation of soil contamination on the area.
- Environmental quality standards +70 substances used in V2 mapping
- Environmental quality standards consist of threshold values for contact risk (soil quality criterion and cut-off criterion, total content mg/kg; evaporation criteria for volatile compounds, mg/m³) and groundwater quality criteria (µg/l) for site-specific risk assessment of risk for groundwater pollution (Danish EPA, 2018)

Soil quality criterion

The soil quality criterion is the level at which the soil can be used freely without having harmful effects on human health – for example for sensitive uses such as housing, children's institutions and playgrounds, where children can come into direct contact with the soil.

Cut-off criterion

The cut-off criterion is used to determine the effort in connection with the clean-up of a pollution. In the cut-off criterion, in addition to how dangerous the contaminated substances are, technical, economic, and practical conditions are also taken into account in the effort. If the cut-off criterion is exceeded, the soil must be mapped, and if the contaminated soil is used for housing, children's institutions or playgrounds, access to the contaminated soil must be cut off.

Advisory interval

The interval between the soil quality criterion and the cut-off criterion is called the

advisory interval, and soil contamination in this interval corresponds to slightly contaminated soil as defined in the *Statutory Order on the definition of slightly contaminated soil* (see more information below).

If the pollution is within the advisory interval in an area of very sensitive use, local authorities must advise owners and users on measures that can reduce the load from the pollution so that the usual level of protection is maintained. As a starting point, only cut-off criteria have been established for the substances listed in the above-mentioned statutory order. An exception to this is antimony, for which a cut-off criterion has been set after the publication of the statutory order.

Evaporation criterion

The evaporation criterion states how much pollution may evaporate from the ground to the outside air or into buildings on the contaminated site, and which can thus affect the indoor climate. The evaporation criterion is basically the same as the air quality criterion.

Groundwater criterion

The groundwater quality criteria set requirements for groundwater under contaminated soils, in publicly funded clean-ups and in the disposal of residual products from waste incineration.

Risk assessment model JAGG

When a soil contamination is detected, the risk assessment is of great importance for how a possible clean-up and remediation is to be administered. In Denmark, risk assessment of soil contamination is done using the risk calculation tool JAGG (Jord-Afdampning-Gas-Grundvand, in English Soil-Evaporation-Gas-Groundwater). The JAGG-model is a key tool for municipalities when it is technically necessary to assess how much pollution needs to be clean up in accordance with the mandatory provisions in the Act on soil contamination.

The JAGG-model can be used to calculate vertical transport of pollutants in the unsaturated zone in addition to risk assessment for groundwater, outdoor air, and indoor air. The model database contains 192 individual substances. For soil samples with oil content, calculations can be made of the substance composition in pore water and pore air. The calculated substance compositions of oil in pore water and pore air can be transferred to corresponding calculation modules for groundwater, vertical transport in the unsaturated zone and risk assessment for groundwater, outdoor air, and indoor climate.

New risk assessment model GrundRisk

The implementation of a new and more accurate calculation tool GrundRisk (Danish EPA, 2021) will, among other things, make it possible to consider the natural pollution degradation that occurs during transport in soil and groundwater. The fact that such natural degradation can be recognized in the future and that the calculations will be more accurate will probably have a major impact on the specific assessment of when a specific pollution can currently or potentially constitute a risk. Thus, the more precise calculations also have great significance for the municipalities' practical administration of the mandatory provisions of the Soil Pollution Act.

The Danish EPA has developed different tools for the assessment of soil contamination and remediation options, all of which are presented in the EPA's homepage (Danish EPA, 2021a).

The statutory order on the definition of slightly contaminated soil

From 1 January 2008, all urban zones are classified as a slightly polluted area. The municipalities have the option of excluding areas within the urban zone, or including areas outside the urban zone in the area-classified areas. The statutory order stipulates what is meant by slightly contaminated soil and determines the limit values for resp. lead, cadmium, chromium, copper, mercury, zinc, PAH total, Benz (a) pyrene, Di-benz (a, h) anthracene, hydrocarbon fraction C20-C35.

The level of pollution for slightly polluted soil is set between soil quality criteria and cut-off criteria. Soil polluted at higher level is regarded polluted soil.

Table 28 Limit values stipulated in the statutory order on the definition of slightly contaminated soil

Pollutants (mg/kg TS)	Category 1	Category 2 Slightly polluted soil
As	0-20	≤20
Cd	0-0,5	≤5
Cr total	0-500	≤1000
Cu	0-500	≤1000
Hg	0-1	≤3
Pb	0-40	≤400
Zn	0-500	≤1000
PAH total	0-4	≤40
Benz(a)pyren	0-0,3	≤3
Dibenz(a,h)antracen	0-0,3	≤3
Hydrocarbon C20-C35	0-100	≤300

Statutory order on notification and documentation in connection with the removal of soil

The statutory order regulates the excavation and removal of soil and contaminated soil from properties, parts of properties, public roads, areas covered by regional classification (urban zones) as well as removal of soil from an approved reception facility for soil. All excavation and removal of soil must be notified to the municipal council, and for the purpose of the notification a special form has been prepared that needs to be filled in. The statutory order sets out minimum requirements for sampling, analysis and classification of soil into pollution categories follow standardized requirements. This means that the soil must be divided into pollution categories 1 and 2 (see Table 28 above) based on the results of chemical analyzes. Digital solutions have been developed to facilitate the handling of the notifications in practice (see previous chapter).

Orientation from the Danish EPA– Information to the municipalities about the statutory order on notification and documentation in connection with the removal of soil (“Orientering til kommunerne om ny jordflytningsbekendtgørelse”) (Danish EPA, 2007)

The purpose of the documents is to help the municipalities to plan and enforce the rules in the statutory order. Furthermore, the intention of the briefing is to ensure that a more uniform practice is established for surplus soil management in the different parts of the country.

Municipalities’ regulations on soil

Pursuant to the Act on soil contamination, regulations on notifications schemes are issued by municipalities, including requirements concerning the notification’s form and content, in some cases requirements as to which digital system to use, as well as requirements and guidance on the classification, sorting and treatment of soil.

A2.1.2 Rules regarding the use of excavated soil

Unpolluted soil

There are different sets of rules and regulations for the management of lightly contaminated and contaminated soil in Denmark. However, in the case of unpolluted soil, permits for utilisation are generally not required. Typically, recycling projects simply must comply with current regulations for e.g., terrain regulation in local plans / rural zone permits. Furthermore, unpolluted soil must not be incorporated to raw material pits without dispensation.

The use of slightly polluted soil and polluted soil is regulated by the statutory order on the use of residual waste, soil and sorted construction and demolition waste, the environmental protection act and the Act on soil contamination.

Statutory order No 1672 of 15 December 2016 on the use of residual waste, soil and sorted construction and demolition waste

The statutory order regulates the use of residual waste, soil and sorted construction and demolition waste. With respect to soil, it only covers heavy metal polluted soil. The statutory order sets out requirements for the notification of use, sampling, analysis and classification in three categories of residual waste and soil based on limit values on content and leachability of several inorganic substances (category 1 – lowest limit values – least polluted materials; category 3 – highest limit values – most polluted materials). The statutory order allows soil to be used for several types of construction works, where applications of soils belonging to category 3 are substantially more restricted compared to the other categories.

§33 (Chapter 5) of the Environmental Protection Act – facilities requiring an environmental permit

For each project, utilizing soil it must be assessed whether the project is covered by chapter 5 of the Environmental Protection Act which regulates polluting companies. A noise barrier is, for example, a listed company which is regulated in accordance with section 33 of the Environmental Protection Act and therefore requires an environmental permit. Both facilities utilizing non-hazardous and hazardous waste are covered. Examples of projects include noise barriers, intermediate storage facilities, dikes and other kinds of construction work.

Examples

Køge Jord-depot - [Om jorddepotet Køge Jorddepot \(koegejorddepot.dk\)](http://Omjorddepotet.KøgeJorddepot.koegejorddepot.dk)

- Environmental permit [Miljøgødkendelser Køge Jorddepot \(koegejorddepot.dk\)](http://Miljøgødkendelser.KøgeJorddepot.koegejorddepot.dk)

KMC Nordhavn - KMC Nordhavn, Jord og Genanvendelse - [KMC Nordhavn, Jord og Genanvendelse \(kk.dk\)](http://KMC.Nordhavn.JordogGenanvendelse.kk.dk)

- Information on acceptance criteria and prices
- Acceptance criteria - limit values for total content
[modtagebetingelser_nordhavn_-_forurenet_jord.pdf \(kk.dk\)](http://modtagebetingelser_nordhavn_-_forurenet_jord.pdf)

§19 of the Environmental Protection Act

If a project utilising excavated soil may pose a risk of contamination of soil and groundwater but is not covered by Chapter 5 of the Environmental Protection Act (which relates to environmental approvals of polluting companies) or the Statutory order No 1672 of 15 December 2016, the project may require a permit under Section 19 of the Environmental Protection Act (protection of soil and groundwater).

The application must describe the project, the degree of soil contamination in the soil to be used, the excavation site, the site's history, analysis and contain a risk assessment of potential soil and groundwater pollution. An example of a project is filling of an excavation with slightly contaminated soil after removal of e.g. foundations / basement filling / cavity filling after removal of soil contamination etc.

Planning act /Environmental Impact assessment (EIA) screening opinion

An EIA screening opinion will help to find out, whether a project/ an installation for waste disposal must undergo an environmental impact assessment according to the rules of the Planning Act. This applies regardless of whether the soil is contaminated or unpolluted, as it only must be waste. All surplus soil from construction projects is regarded waste. An EIA screening opinion must be available before an environmental permit can be granted in accordance with the Environmental Protection Act. It is the responsibility of the municipality where soil is to be utilized to carry out this assessment of whether the project can be regarded as a facility.

§8 Act on soil contamination

For certain types of pollution-mapped properties, section 8 of the Act on soil contamination may, among other things, be included in a permit to use contaminated soil within a property. Typically, permits pursuant to section 8 will involve very limited quantities, for example minor terrain regulation or refilling for pipeline routes. In many cases, permits for building and construction work on contaminated land are combined permits pursuant to section 8 of the Soil Pollution Act and section 19 of the Environmental Protection Act.

The Landfill Order (Deponeringsbekendtgørelsen) prescribes the technical and financial requirements that apply to landfills in connection with establishment, operation, decommissioning and finishing. When waste is covered the final cover must be made with a minimum of 0.5 m of unpolluted soil at the top and can be made with up to 0.5 m of unpolluted soil or category 2 soil at the bottom

Technical requirements - The Danish Road Directorate's tender regulations for soil stabilization

The background for the tender regulations for Soil Stabilization (Vejdirektoratet, 2018) is the desire to provide a uniform technical basis partly for the contractors 'bidding and partly for the road authorities' treatment of the execution of soil stabilization. The purpose of the tender regulations is to describe the requirements for the quality of the work performed, and how the contractor must ensure the quality of the work performed, so that damage in the form of irregularities, sentences, cracks, etc. as well as wear and tear on the road systems can be reduced.

When preparing the tender regulations for Soil Stabilization, the focus is primarily on use where the soil has too little load-bearing capacity and / or is too soft for compaction. The use of soil stabilization / soil improvement allows the use of materials that would otherwise be discarded. Furthermore, soil stabilization / soil improvement can contribute to increased progress of the work.

The term soil stabilization is used when working with improved load-bearing capacity of raw soil planum. Stabilization of soil can be achieved with burnt lime (calcium oxide) or cement or a combination of both depending on the properties of the soil to be stabilised.

Strategies, guidance documents, best practise and new/upcoming legislation

More efficient management of excavated soil has received attention throughout the past years, where focus has been on the mapping of qualities and quantities, rules and policy instruments as well as on the development of guidance and best practise (e.g. Jensen & Bengtsson, 2011; Jensen et al., 2017).

Project on holistic sustainable soil management ("Helhedsorienteret bæredygtig jordhåndtering")

The project was carried out in 2014–2016 and addressed among other things the potential economical savings of on-site/local utilisation of excavated soil. The results of the project and its 9 sub-projects are compiled and made available from the [project homepage](#), containing planning and decision-making tools, guidelines, paradigms, tools, etc.

The project consisted of the following 9 subprojects:

1. Approval scheme for soil samplers
2. Planning approaches
3. Local soil management
4. Portal for the exchange of surplus soil
5. Soil cultivation
6. Surplus soil on agricultural land
7. Recreational landscapes
8. Climate adaptation with surplus soil
9. Surplus soil in energy plants

Project on sustainable Soil Management (Bæredygtig jordhåndtering - Region Midtjylland)

In 2018 another project followed suit – Region Midtjylland initiated a project on sustainable soil management that resulted in the following four tools:

- Forecasting tool for excavated soil, including estimation of the potential economic and environmental savings for the local use of excavated soil ([regional-analyse-af-jordproduktion.pdf \(rm.dk\)](#))
- Inspiration catalogue - The inspiration catalogue consists of different types of projects where surplus soil is used as a resource in the project. There are both projects with climate protection, landscape, noise reduction etc. The projects are of varying size and are distributed geographically. The projects are intended to inspire people to work with sustainable soil management in different project types ([inspirationskatalog-for-baredygtig-jordhandtering.pdf \(rm.dk\)](#)).
- Template for soil management strategy (to be downloaded [her](#))
- Guidance document to municipalities on the preparation of a soil management strategy ([projektvejledning---til-udarbejdelse-af-strategi-for-baredygtig-jordhandtering.pdf \(rm.dk\)](#))

Municipal strategies on soil management

Several municipalities have developed strategies for soil management in order to set focus on the more efficient use of surplus soil.

Examples

Strategi for jordhåndtering - Vordingborg Kommune - [Strategi for jordhåndtering - Vordingborg Kommune](#)

Strategi for jorden i København 2008–2015 - can be downloaded [here](#)

Strategi for jordhåndtering 2017–2029, september 2017, [Microsoft Word - Jordstrategi Horsens Kommune rev20170924_ENDELIG.docx \(skanderborg.dk\)](#)

A2.2 Swedish policy instruments and strategies

A2.2.1 National legislation

Swedish legislation having an impact on natural occurring masses and their handling are:

- The Swedish Environmental Code (998:808)

The purpose of the Environmental Code is to promote sustainable development and is applicable to all who undertake activities or measures which could impact on the fulfilment of the Code's objectives. The Swedish definition of waste contained in the Environmental Code is based on waste definition in the EU Waste Framework Directive (2008/98 / EC). According to chapter 15 and 1§, waste is defined as any substance or object which the holder discards or intends or is required to discard.

Regarding natural occurring masses, the Swedish Environmental Protection Agency assesses that excavated masses is not to be regarded as waste if the masses are excavated and used at that site where the excavation was carried out within a reasonable time (Naturvårdsverket, 2016). If it is not certain that the masses will be used or if the use cannot be foreseen other than in the long term, they are thus waste according to the definition of waste, according to the Swedish Environmental Protection Agency.

In the same section in the Environmental Code, the term by-product is defined as a *"substance or object which has been generated in a production process where the main purpose is not to produce the substance or object if the following requirements are met:*

1. *it is ensured that the substance or object will continue to be used;*

2. *the substance or object can be used directly without any processing other than that which is normal in industrial practice*
3. *The substance or object has been produced as an integral part of the production process and*
4. *the use referred to in 1. does not contravene any law or regulation and does not lead to generally negative consequences for the environment or human health."*

As for natural occurring masses the Swedish Environmental Protection Agency states that generated masses can't be considered as by-products as they have not been generated in a manufacturing process according to 3) above (Naturvårdsverket, 2016). However there has been a court case in Sweden where the Environmental Court ruled that rock masses that would not be used within the project was classified as by-products. This if they needed to meet the criteria in chapter 15 and paragraph 1 of the Environmental Code (Nacka tingsrätt, 2014)

The Swedish Government has issued three ordinances based on the Environmental Code and chapter ten, contaminated land with:

- SFS 2007:667 Ordinance on serious environmental damage (Förordning om allvarliga miljöskador)
- SFS 2004:100 Ordinance on the remediation of pollution damage and state aid for such remediation (Förordning om avhjälpande av föroreningssskador och statligt stöd för sådant avhjälpande)
- SFS 1998:930 Regulation on environmental risk areas (Förordning om miljöriskområden)

From these legal acts the SEPA has issued national guidelines, ordinances, methods and tools for inventory, identification, classification, risk assessment and remediation of contaminated land.

In chapter 11 of the Environmental code all activities regarding fresh- and marine water is regulated. This includes sediments and thereby dredging and building structures in contact with the water body. If the sediments is to be used outside of the water body, then legislation in chapter 10 applies. In general, concerning all types of masses to be handled, the waste ordinance is always mandatory if the level of hazardous substances can give the material classification as hazardous waste.

- The waste ordinance (2020:614)

The Waste ordinance contains provisions on waste and waste management in Sweden. As for natural occurring masses, the ordinance is only applicable if the masses are considered as waste, see under the Environmental Code above. The waste categories are listed in Appendix 4 to the ordinance using the same nomenclature as the *European list of waste*.

- Environmental assessment ordinance (2013:251)

In the Environmental Code, there is a distinction between activities which require an environmental permit and activities for which a notification to the authorities is sufficient. The difference is based on the risk of an impact on health and the environment where activities requiring environmental permits are assessed as having

a considerable impact on the environment.

Which activities require a permit and notification are defined in the Environmental assessment ordinance (20213:251). Chapter 29 of the ordinance concerns facilities that handle waste and the chapter defines which facilities are subject to an environmental permit respectively a notification requirement, depending on the type of treatment, size and type of waste received and associated waste amounts.

Regarding masses classified as waste intended for construction purposes such as noise barriers etc, it is the health and environmental risks and not explicitly of the quantities which are handled which is decisive if an environmental permit is needed or if a notification is sufficient. If the risk of pollution is estimated to be less than low, no notification is required at all.

In the handbook "Recycling of waste for construction purposes" provided by the Swedish Environmental Protection Agency, there are indicators to distinguish between activities without notification obligation, notifiable activities, and activities subject to an environmental permit (Naturvårdsverket, 2010).

Regarding natural occurring masses, chapter 4 of the ordinance, is also of relevance.

- Waste Tax Act 1999:673

Landfilling facilities receiving waste are obligated according to the waste tax act 1999:673 to pay a landfill tax which today amounts to about 500 SEK/ton of waste. As mentioned previously there are exemptions when the tax is not applicable. One such exemption is landfills which only receive naturally occurring masses such as soils, gravel, rocks, rock debris etc. In addition, when waste is used for construction purposes and similar at the landfill site, the operator of the landfill can deduct the entire landfill tax.

- Tax on natural gravel (1995:1667)

To promote the use of secondary masses there is today a tax on natural gravel which today amounts to 17 SEK/tonne. Natural gravel refers to naturally sorted soils that predominantly consist of the fractions sand, gravel, and stones.

- The Planning and Building Act (2010: 900)

The provisions of the Planning and Building Act on supervision and control at demolition measures are aimed at the appropriate disposal of hazardous waste and to provide conditions for recycling and recovery of demolition waste.

A2.2.2 National guidelines

To guide and help authorities as well as actors to comply with the legislations a number of national guidelines have been developed related to natural occurring masses. They are listed below. In short for products and by-products legislation on products apply. For wastes relevant waste legislation applies.

- Residual flows classified as waste or by-products

This guide is intended as an aid in determining whether a residual product should be

classified as a by-product or waste. Such a classification is decisive for the rules that apply to the handling of the residual product. For by-products, the waste legislation is not applicable why use and handling are regulated in product legislation such as REACH (Naturvårdsverket, 2021).

- Handling surplus masses in infrastructure project

In this guide from the Swedish environmental protection agency, guidelines are given how to classify surplus masses arising from the construction of roads and railways (Naturvårdsverket, 2016). Each project is considered specific and what's valid in other projects does not apply automatically.

- Recycling of waste in construction projects- handbook

The handbook published by the SEPA aims at facilitating the recycling of waste including natural occurring masses in construction work in an environmentally and health-safe manner (Naturvårdsverket, 2010). As mentioned above, the handbook provides indicators to distinguish between activities without notification requirement, notifiable activities, and activities subject to an environmental permit. This guide will soon be replaced.

- Guidelines and assessment scenarios for contaminated land

The SEPA has developed a guideline and model for calculation of reference values for contaminated land (Naturvårdsverket, 2009). Calculations and reference values was updated in 2016.

A2.2.3 Risk assessment

Depending on planned and wanted use of materials, classification, origin etc. different approaches are used for risk assessment. The base of the risk assessments is, regardless, criteria and hazards for human health and the environment. The different approaches are described below.

For contaminated land and land use with levels of chemical substances above the baseline the SEPA has a series of publications called "Principles for assessment of environmental quality" which is used by the environmental authorities on regional and local level and when applicable for other authorities. Risk assessment guidelines for contaminated land and use of land is a part of the method for inventory of contaminated land (Naturvårdsverket, 1999; 2009).

In the methodology there's two steps:

- phase 1 oriented desktop analysis and basic risk classification in class 1–4
- phase 2 overview survey with basic sampling, analysis, and evaluation with new risk classification as result

It's not common practices to use the risk classification 1–4 in surveys other than that performed by authorities but the method for investigation and perform risk assessment is used by the environmental consultants, entrepreneurs etc. Risk classification has however been made for land used by different types of industries, with the latest update in 2020 (Naturvårdsverket 2020c). The purpose of this work

was to identify all known contaminated land areas in Sweden and in the end of 2015 this task was ended. All data from the investigations can be found in a national database. Focus on the ongoing work is remediation of the areas with the highest risk classification.

General target values for contaminated land have been calculated by the SEPA with the latest update made in 2016.

There's two basic scenarios in the general target value calculations:

- Sensitive use of land (in Swedish känslig markanvändning, KM)
- Less sensitive use of land (in Swedish mindre känslig markanvändning, MKM)

In Table 29 the general target values can be seen for some chosen parameters for the two risk scenarios.

Table 29 General target values for contaminated land for the two scenarios Sensitive use of land and Less sensitive use of land.

Swedish environmental Protection Agency, version 2.0.1			
Sweden Environmental protection Agency's general target values for contaminated land (mg/kg TS). KM = Sensitive use of land och MKM = Less sensitive use of land (table published June 2016).			
Table of general target values for contaminated land			
Substance	Sensitive use of land	Less sensitive use of land	Comments
Antimony	12	30	
Arsenic	10	25	
Barium	200	300	
Lead	50	400	
Cadmium	0,8	12	
Cobalt	15	35	
Copper	80	200	
Chromium total	80	150	If the share of Chromium (VI) is >1% of the total level of Chromium then risk assessment of Chrome (VI) must be performed
Chromium (VI)	2	10	Remark 2
Mercury	0,25	2,5	
Molybdenum	40	100	
Nickel	40	120	
Vanadium	100	200	
Zinc	250	500	
Cyanide total	30	120	
Cyanide free	0,4	1,5	Remark 2
Sum phenols and cresols	1,5	5	Remark 2
Sum chlorophenols (mono - penta)	0,5	3	Remark 2
Sum mono- and dichlorobenzenes	1	15	Remark 1, 2
Trichlorobenzenes	1	10	
Sum tetra- and pentachlorobenzenes	0,5	2	
Hexachlorobenzene	0,035	0,1	
Dichloromethane	0,08	0,25	Remark 1, 2
Dibromochloromethane	0,5	2	Remark 1, 2
Bromodichloromethane	0,06	1	Remark 1, 2
Trichloromethane	0,4	1,2	Remark 1, 2

Tetrachloromethane	0,08	0,35	Remark 1, 2
1,2-dichloroethane	0,02	0,06	Remark 1, 2
1,2-dibromothane	0,0015	0,025	Remark 1, 2
1,1,1-trichloroethane	5	30	Remark 1, 2
Trichloroethene	0,2	0,6	Remark 1, 2
Tetrachloroethene	0,4	1,2	Remark 1, 2
Dinitrotoluene (2,4)	0,05	0,5	Remark 2
PCB-7	0,008	0,2	PCB-7 is assumed to be 20% of PCB-tot
Dioxin (TCDD-ekv WHO-TEQ)	0,00002	0,0002	Includes PCB:s with properties of Dioxine
PAH-L	3	15	PAH with low molecular weight
PAH-M	3,5	20	PAH with medium molecular weight
PAH-H	1	10	PAH with high molecular weight
Benzene	0,012	0,04	Remark 1, 2
Toluene	10	40	Remark 1, 2
Ethylbenzene	10	50	Remark 1, 2
Xylene	10	50	Remark 1, 2
Aliphatic >C5-C8	25	150	Remark 1, 2
Aliphatic >C8-C10	25	120	Remark 1
Aliphatic >C10-C12	100	500	Remark 1
Aliphatic >C12-C16	100	500	
Aliphatic >C5-C16	100	500	The sum of aliphatic fractions above
Aliphatic >C16-C35	100	1000	
Aromatic hydrocarbons >C8-C10	10	50	
Aromatic hydrocarbons >C10-C16	3	15	
Aromatic hydrocarbons >C16-C35	10	30	
MTBE	0,2	0,6	Remark 1, 2
DDT, DDD, DDE	0,1	1	
Aldrin-Dieldrin	0,02	0,18	
Quintozene-pentachloroaniline	0,12	0,4	
Organic tin compounds	0,25	0,5	
Tributyltin (TBT)	0,15	0,3	
Dibutyltin (DBT)	1,5	5	
Monobutyltin (MBT)	0,25	0,8	
Irgarol	0,004	0,015	
Diuron	0,025	0,08	

Remark 1 Substances that can to a large extent occur in pore gas. Supplementary analyzes of ground air and indoor air are recommended
Remark 2 Substances that can to a large extent occur in groundwater. Supplementary analyzes of groundwater are recommended.

The parameters chosen in the general target values are considered commonly available in land use for human activities. Typical hazardous substances from dredged sediments, plant protection activities (pesticides in cultivated land), petrol stations, workshops, wood protection and other normal activities are included in the general target value calculations. Unlimited number of substances can be added in the model for calculation of specific scenarios. Data on each new substance must then be added in the model.

In this work, a project group performed the task with participation by the Swedish Geotechnical Institute (SGI) and Environmental Medicine Department on the Karolinska Institute and others.

The target value calculations are based on risks for human health, the environment, and natural assets such as ground water acquihires. The principle behind the model is safe use for human activities and the environment. This includes input data on hazardous substances, sources, transport mechanisms, risk for exposure and objects to protect.

For the scenario with *Sensitive use of land*, the boundaries are typically that for land where healthy adult humans can be every day, the entire time and for a lifetime, with an acceptable risk for damage to the health. This also includes typical normal land use such as growing crops for food production and having small children playing on the ground. For *Less sensitive land use*, the land use is typically of that for a work environment i. e. use of the land for 8 hours a day, 5 days a week during 40 years of working life. The *Less sensitive land use* scenario does not include growing crops for food but include examples with kindergartens, schools and recreation parks. When there's data on different use of the land from that of the two different scenarios, the SEPA model can be used to calculate site specific target values.

In general, the method is used to give data for assessing if a land area or masses can be used as Sensitive use of land or Less sensitive use of land, in existing real estates or in planned projects (Naturvårdsverket, 1999).

Risk assessment regarding materials within the waste definition that also can be used technically as soil or ground construction material is regulated through the handbook NV 2010:1 (Naturvårdsverket 2010). Due to complications in the interpretation of the guidelines there are also external support documents. The Swedish Waste Management and Recycling association (SWMRA) members are the municipalities and other organisations with interest in long term goal for improved waste management. The SWMRA has published a report on methods for risk assessment of masses regarding waste classification. The types of masses included in the methodology are soil and rock, dredging spoils as well as track ballast (see also Table 2).

The report includes procedures for sampling, examples on parameters to analyse, evaluation criteria regarding legislation on waste and on chemical substances (REACH and CLP) and a proposal for risk assessment has been made for the examples included.

In practice both classification of waste and risk assessment regarding the scenarios *Sensitive use of land* and *Less sensitive use of land* are made in planning and projects with masses. However, if the scenario *Less sensitive use of land* or lower levels of contamination is reached, then waste code hazardous waste is automatically not possible and waste code non-hazardous waste can be used. The

Less sensitive use of land scenario is ten-fold or lower in contamination level than that for hazardous waste depending on type of material and substances included in the risk assessment.

Natural unpolluted masses can be classified as waste depending on results from the risk assessment. In a recent case from the Swedish Environmental Court the ruling defined natural soil with high levels of sulphides as waste. The Swedish Transport Administration, the project owner, was also ruled by the court to apply for setting up a landfill on-site with surveillance and protection of the environment due to the risk assessment.

Other naturally occurring chemical and physical parameters can affect the risk assessment of natural unpolluted masses. As for sulphides it's primary the redox potential in the environment that give rise to acidic conditions and negative effects in the environments. Similar can be seen for other parameters, for example ammonium, chloride, fluoride, sodium, and calcium. In local areas in Sweden the natural levels of metals can be high enough for negative consequences for the environment. As an example, the levels of copper can be high in the region of Dalarna and thus limit the possible use of excavated soils due to the risk assessment.

The natural level of radioactive isotopes in rock and soil can affect the classification as waste or non-waste and the risk assessment for land use. As an example, demolition waste with light weight concrete with high levels of isotopes (uranium, thorium, and radium) giving radon gas in buildings is allowed in land use other than that where buildings are placed (the Swedish Radiation Safety Authority). The risk assessment made by the Swedish Radiation Safety Authority and the National Board of Housing, Building and Planning confirms that radon is an indoor health risk and not an environmental risk. The binder material can however cause leaching of salts and affect pH level in bodies of water why the use is restricted to urban areas such as parking lots and landscaping projects.

For dredged sediments and spoils risk assessment is made regarding volume, time of year, local restrictions, wanted use and planning. Re-use of dredged material in minor amounts within the local area can often be made with a simple notification to the local municipality and to the Swedish Agency for Marine and Water Management. Concerning larger volumes and with uncertainty in content of hazardous substances it's mandatory with a survey for both overview and detail purpose. Notification and process in the Swedish Environmental Court is mandatory with local, regional and national authorities involved in the risk assessment process. Guidelines for marine sediments is not available in Sweden regarding classification of contamination level and risk assessment. In general, the Norwegian guidelines has been mandatory for use in risk assessment in the Environmental court. There is an ongoing project at the Swedish Geotechnical Institute to publish Swedish national guidelines for risk assessment of marine sediments.

There's also example in Sweden when contaminated sediments have been used as construction material post solidification and stabilization with a binder. Examples of this can be found in the port of Gävle, Oskarshamn and Gothenburg. In the case from the port of Gothenburg the risk assessment was made by sampling and testing for content and leaching behavior of contaminants, by crushing and by diffusion from a monolithic body, as well as geotechnical properties such as load bearing capacity, curing time, long term durability and risk for effects from climate change.

A2.2.4 Sampling and sampling procedures of masses

For sampling, analysis and evaluation of results for masses to be used on land there's several tools available in Sweden. The SEPA handbook "Methods for Investigation of contaminated land" (Naturvårdsverket, 1999) and The Swedish Geotechnical Society (SGS) handbook on sampling of contaminated land (Swedish Geotechnical Society, 2013) are well known. The SGS has certification procedures on sampling in general with additions for soil, ground water, surface water and sediments. The certification is made according to Nordtest standard NT Environ 008 which in Sweden is performed by Kiwa Sverige AB (fd Swedcert).

The certification as sampler is not mandatory for sampling of masses. It's often a demand that the sampler has experience and knowledge in level with the demands in the certificate for soil sampling by NT Envir 008. According to demands in the EU legislation on competition it's illegal for Swedish companies, authorities, and other organizations to set specific demands for sampling certificates unless it's available throughout the EU. Thus, to avoid legal complications demands is set to "...certified according to Nordtest NT Environ 008 or equally valued competence...".

The SGS certified sampling method for soil is considered BAT in the "Clean Soil Network" (<http://www.renaremark.se/>) which include the majority of the consultants who perform sampling of masses. The methodology includes setting up a sampling plan with the local municipality as an important part in the planning step. The method includes standardized sampling and testing methods, certification of sampling personal, sampling strategies, how to perform sampling, handling, and storage of samples for laboratory analysis, sampling for in-situ analysis and sample preparation such as leaching and bioaccumulation. The quality assurance work includes documentation of sampling procedure and analysis results, collection of data and analysis of data, calculation and estimation of minor and major errors and evaluation of analysis and sampling data etc.

The sample origin, characteristics and planned use also determine what demands there are for sampling and analysis. Classification as waste require analysis in two steps. Step 1 determination of levels for each required parameter. Step 2 is performed if parameters have levels above reference value, and the testing of leaching from the sample matrix is made. Depending on sample matrix, parameter to analyze and the environment for use of the material, there are different standard methods. For inorganic substances, the sample is crushed or milled to a specific particle size (4 mm) and tested by shaking method EN 12457. Water is used as solvent and depending on scenario of interest different ratio between liquid and solid is used. The L/S ratio of 2 and 10 is used for long time simulations of leaching from rainfall. The leachate is analyzed for the chosen parameters and the results evaluated against reference values. Test methods for percolation, surface diffusion, organic substances and more are also available.

To assess whether a waste can be used for construction purposes, the facility/ organization planning to use the masses are responsible for collecting necessary information about the properties and content to make an assessment. This as part of the self-inspection in the Swedish environmental code.

For masses to be able to be handled in the right way and by the right recipient it is required that representative samples be taken and analyzed with respect to relevant parameters.

The only exception to sampling might be masses that are excavated from well known, virgin land outside urban areas (e.g. forest or arable land that is being prepared to plots of land). Since it is difficult to establish when sampling is needed it is recommended to always take samples (Magnusson G., (2018).

It is impossible to specify that a certain number of samples per unit volume should be taken for analysis. This since there are many factors that determine such as - the origin of the masses, types of pollution and what the masses are to be used for etc. Extent of the sampling may therefore take place in consultation between the operator and the authority (usually the municipality) for the intended place for the masses (Magnusson G., (2018).

As mentioned earlier, the Swedish Environmental Protection Agency has developed general benchmark values for several commonly occurring contaminants in soil to compare the analyses against. The benchmark values can be used as a tool in the risk assessment to determine whether an area needs to be treated and is classified into:

- less sensitive land use can be used when assessing land areas to be used for, for example, industry and offices
- sensitive land use assessing land to be used for, for example, housing.

, as mentioned above.

In addition, benchmark value less than low risk has been developed as well, under which not even a notification to the authority is needed, see under "Environmental assessment ordinance (2013:251) above. The benchmark values can be used as a tool in the risk assessment to evaluate if an area needs to be treated, but not used decide whether the masses can be utilized in other places. Acceptable levels of contaminants for masses at the site where they will be utilized must be assessed in each individual case. The same methodology is applied as for on-site utilization, see above in this subchapter.

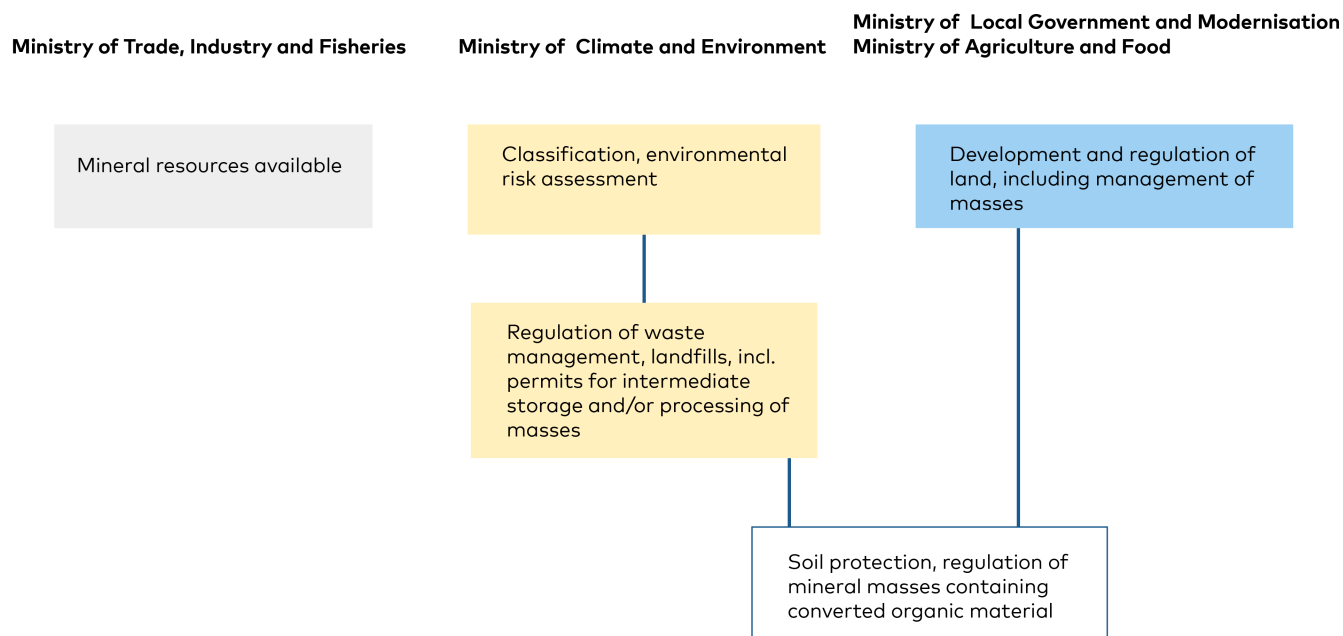
A2.3 Norwegian policy instruments and strategies

A2.3.1 National legislation

Management of naturally occurring masses in Norway is regulated by several laws and regulations across sectors (e.g., environment/pollution, planning and building, waste management, agriculture, etc.) and by several authorities – both national, regional and local. A simplified illustration of the involved sectors is shown in Figure 10.

Note that regulation of mineral resources is not included in the scope of this study but is included in the box diagram under for context. It is worth mentioning that the supply of minerals as building materials are regulated by a separate (regional) authority (Directorate of Mining with Commissioner of Mines at Svalbard, DMF) than the ones regulating the management of natural materials.

Figure 10 A simplified box diagram showing the regulation of naturally occurring materials across sectors in Norway.



In general, legislation concerning excavated materials defines it as trade waste and the materials are in general managed as such. It should be noted that the waste definition follows from the implementation of the EU Waste Framework Directive. Re-use and recycling of natural materials are regulated by the same legislation under Ministry of Climate and Environment.

Most relevant legislations are:

- Norwegian Pollution Act § 27a, which defines all excess materials from C&D activities as waste.
- Norwegian Pollution Act § 32, which states that waste – if it is not sent to recovery/recycling – shall be disposed to a regulated waste plant or landfill approved by the authorities.
- Norwegian Pollution Act § 11, which states that no one can implement activities that can cause pollution.

One must apply to The Norwegian Environment Agency for exception from Pollution Act § 32 a) in order to dispose the waste materials outside an approved waste plant or landfill if not certain defined criteria's in Norwegian EPA fact guidance are fulfilled, e.g.

- The possibility to re-use or re-cycle the materials has been investigated
- The disposal is in accordance with regulation in the Planning and Building Act
- The disposal is on land, not in sea or other waterbodies.

The Norwegian EPA is currently working on an Act to regulate the management of excess unpolluted materials generated in construction activities.

In general, it is the municipalities that approve the management of polluted soil in C&D projects, by approval of remediation plans for polluted soil and Pollution Regulation Chap. 2. In general, the national or regional authority (the Norwegian EPA or County Governor) approves remediation plans for projects with aims to remediate a polluted site and/or pollution from special businesses.

A2.3.2 Legislation regarding the use of excavated and mechanically excavated materials

Disposal of excavated soils outside landfills must also be in accordance with local municipalities' zoning plans (Planning and Building Act), the Biodiversity Act (naturmangfoldloven), Water Framework Directive (vannforskriften), Soil Act (jordloven) and other relevant legislation.

A2.3.3 Legislation regarding classification, excavation and removal of soil

In addition to the EU waste codes shown in Table 2, Norway has a national set of waste codes, as shown in Table 30.

Table 30 National waste codes in Norway (Standard Norge, 2011).

Waste code	Classification term	Explanation
1601	Clean masses	Soil, stone, gravel, etc. that do not exceed the standard values in Chapter 2, Appendix 1 of the Pollution Control Regulations, i.e. lower than condition class 1 in Figure 11, but the list is much longer.
1603	Lightly polluted masses	Soil, stone, gravel and other non-hazardous waste that satisfies criteria for reception at a landfill for inert waste, cf. Chapter 2, Appendix 1 of the Waste Regulations.
1604	Polluted masses	Soil, rock, gravel that is contaminated but not classified as hazardous waste, i.e. higher than condition class 5 in Figure 11.
1605	Clean dredging spoils	Sediments where the concentration of environmentally hazardous substances does not exceed set limit values for good chemical condition (condition class II or cleaner in the Norwegian Environment Agency's system for classifying environmental hazardous substances in sediments), or concentrations of other environmentally hazardous substances which, after a risk assessment, are equated with these.
1606	Polluted dredging spoils	Sediments that are polluted, i.e. where the concentration of environmentally hazardous substances exceeds set limit values for good chemical condition (condition class III or more in the Norwegian Environment Agency's system for classifying environmental toxins in sediments), but not classified as hazardous waste.

A2.3.4 Classification of unpolluted materials

Unpolluted materials are classified as unpolluted if they do not contain substances that can pose a risk to health and environment (e.g. excluded from the definition of polluted soil in the Norwegian Regulation of Pollution, chap. 2, § 2–3 a) and other criteria given by the Norwegian EPA guidance, e.g.

- affect the pH in medium at the site of deposition (acid forming shale).
- the disposal must not lead to the spread of particles or organic material which can pose a risk to the environment at the disposal site.

The soil must also be free of invasive plant or animal species but does not affect the classification above.

A2.3.5 Classification and risk assessment of polluted materials

Polluted materials defined by Norwegian Regulation of Pollution § 2–3 a) as soil that contain substances that can pose a risk to health or environment and concentrations of toxins exceeding the limit values in the Norwegian Regulation of Pollution, chap. 2, appendix I. The pollution level is measured as the total concentration in the material (mg/kg dry material).

The polluted material is further classified according to the Norwegian Environmental Agency's guideline for health risk-based classification of polluted soil (guideline TA-2553/2009), see Figure 11. The classification is from class 1 – Very good (e.g. unpolluted), class 2 – Good, class 3 – Moderate, class 4 – Bad and class 5 – Very bad. Class 2 is allowed in the top meter (0–1 m under terrain) on land used for sensitive purposes, e.g. accommodation, pre-school, schools etc. Class 3 is allowed in the top meter of city centres, commercial buildings etc. Class 4 is allowed in the top meter of roads, industry etc.

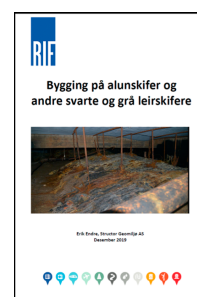
Figure 11 Norwegian condition classes for slightly polluted soil.

		Condition class				
		1	2	3	4	5
		Very good	Good	Poor	Bad	Very bad
As	mg/kg dw	8	8-20	20-50	50-600	600-1000
Cd	mg/kg dw	1,5	1,5-10	10-15	15-30	30-1000
Cr	mg/kg dw	50	50-200	200-500	500-2800	2800-25000
Cu	mg/kg dw	100	100-200	200-1000	1000-8500	8500-25000
Hg	mg/kg dw	1	1-2	2-4	4-10	10-1000
Ni	mg/kg dw	60	60-135	135-200	200-1200	1200-2500
Pb	mg/kg dw	60	60-100	100-300	300-700	700-2500
Zn	mg/kg dw	200	200-500	500-1000	1000-5000	5000-25000
Cr6+	mg/kg dw	2				1000
Sum PCB-7	mg/kg TS	0,01	0,01-0,5	0,5-1	1-5	5-50
Sum DDT	mg/kg TS	0,04				50
Benzo(a)pyrene	mg/kg TS	0,1	0,1-0,5	0,5-5	5-15	15-100
Sum PAH-16	mg/kg TS	2	2-8	8-50	50-150	15-2500
Aliphates >C8-C10	mg/kg TS	10	10	10-40	40-50	50-20000
Aliphates >C10-C12	mg/kg TS	30	30-60	60-130	130-300	300-20000
Aliphates >C12-C35	mg/kg TS	100	100-300	300-600	600-2000	2000-20000
Phenol	mg/kg TS	0,01	0,1-4	4-40	40-400	400-25000
Benzene	mg/kg TS	0,01	0,01-0,015	0,015-0,04	0,04-0,05	0,05-1000
Tetraklorethene	mg/kg TS	0,1	0,01-0,2	0,02-0,6	0,6-0,8	0,8-1000

In addition, soil and rock masses originating in acid-forming rocks, e.g. alum shale, is always considered contaminated unless otherwise documented. Consulting Engineers' Association has published a guideline for handling acid-forming slate.

A2.3.6 National, regional and local guidelines

The Norwegian EPA published a fact sheet (M-1243) in 2018 with guidelines for management of unpolluted soil. The fact sheet was only a clarification of current regulations. Nevertheless, this created several challenges and frustration. From then on, all unpolluted masses were regarded as trade waste, and this meant that all mass tips had to be approved by the authorities as landfills for industrial waste.



There was thus also a need for the municipalities to set aside areas for mass handling in municipal plans, which had not been done. Such challenges can in all probability be solved in large projects that are planned over many years, but what does a small machine contractor do that will create a 1.2 km long pedestrian and bicycle path? Where should he deliver his surplus masses in a legal way?

The fact sheet originally stated that if surplus masses were to be disposed of in any other way than to be delivered to legal deposit or recycled, an exception had to be applied for. The fact sheet was revised in 2019 because the authorities are working on a new Regulation of the management of unpolluted naturally occurring materials. Until new regulations have been adopted, it is therefore not necessary to apply for an exemption, as discussed above.

As described above, it is a National guideline for assessment and management of polluted soil in the Norwegian EPA guideline for health-based classes for polluted soil, TA-2553 published in 2009. The classification system was elaborated on in chap. 9.3.5

There are also some regional and local guidelines:

- Trondheim municipality has developed a local guideline for management of polluted soil (fact sheet 63) with specific local limits for some substances occurring naturally in high levels. This allows developers to re-use more fractions of polluted soil within the project instead of handling the soil according to the national guidelines (guideline TA-2553/2009) which state that the soil is transported to landfills.
- There are several regional plans for management of masses, with guidance to the local municipalities and aim to enhance re-use of materials, see references in chap. 2.

A2.3.7 Upcoming legislation

As mentioned in Table 3, a cross-sectoral project will be implemented that looks at possible measures and instruments to achieve better management of non-contaminated surplus masses of soil and rock. 11 directorates and agencies have been commissioned by their ministries to contribute to the project within their fields. A report is expected in September 2021.

A2.3.8 Summary

The Norwegian regulations are relatively clear, which was described in detail in the Norwegian Environment Agency's fact sheet M-1243. The problem is that there are many laws and regulations that can be applied, and many different administrative bodies that have authority. The challenge is therefore that the industry has problems implementing this in practice. It is our impression that surplus masses have mainly been disposed of in the cheapest possible way. Lighter contaminated soil and contaminated soil have long been handled correctly. But we believe that the regulations have been practiced differently in different parts of the country. It is somewhat open what the outcome of the work of the interdisciplinary group will be, but it is at least expected that the regulations will be clarified.

A2.4 Finnish policy instruments and strategies

A2.4.1 National legislation

The national legislation concerning the utilization and disposal of surplus landmasses is listed below:

- Waste Act 646/2011 and Decree 179/2012
- Land Extraction Act 555/1981 and Decree 926/2005
- Land Use and Building Act 132/1999 and Decree 895/1999
- Act on Environmental Impact Assessment Procedure 252/2017
- Environmental Protection Act 527/2014 and Decree 713/2014
- Waste Tax Act 1126/2010
- Government Decree on the Assessment of Soil Contamination and Remediation Needs 214/2007 ("PIMA Decree")
- Government Decree on Landfills 331/2013

Waste Act 646/2011

The Act only applies to soils (i.e. rock or soil material excavated in connection with construction or similar activities) in case the soil is classified as waste. The management and use of non-waste material do not require an environmental permit either. Waste Act does not either apply to uncontaminated dredged mass that is managed based on a notification or a permit in accordance with the Water Act (Section 3), whereas the provisions of the Waste Act are applied to dredging masses disposed on the land. Nor does it apply to contaminated soil that is not excavated from bedrock or ground, as this waste type is excluded from the scope of the Waste Directive 98/2008/EY. (Ministry of the Environment 2015)

When assessing whether excavated soil is regarded waste or non-waste, Section 5 in the Waste Act is applied. The basis of the Waste Act is that soil or other material of natural origin that is excavated as a result of construction or other similar activities and which is not contaminated, for which further use is certain, and that will be used directly or after sieving or other similar preparation for construction purposes on site or elsewhere, rarely meets the general characteristics of waste. If all of the following criteria are met, the soil excavated from construction site is not considered as waste (according to Section 5), but should meet all the requirements of the product legislation for the product in question, or other general technical requirements if product legislation does not exist:

- If the concentration of contaminants in the soil do not cause environmental pollution or its danger
- If the further use is certain (i.e. the soil is directly delivered to the utilisation site and it is not stored for long)
- If the further use is systematic (i.e. there is a genuine need for the soil, and relevant planning, notification or permit procedures are carried out), and;
- If the soil can be used directly without any further processing (excluding mechanical pre-treatment). (Ministry of the Environment 2015)

The treatment of soil materials defined as waste shall comply with the waste hierarchy (according to Section 8). An operator who treats waste on a professional basis must comply with this order as a binding obligation. Firstly, the amount and harmfulness of waste generated should be reduced. If waste is nonetheless generated, it should be prepared for reuse or secondarily recycled. If recycling is not possible, waste should be recovered for example as an energy, or if this is not possible, disposal shall be carried out.

The treatment of soil waste shall not pose hazard or harm to human health or the environment. The uncontaminated soils excavated from construction site should be primarily utilised in the same site (e.g. in environmental constructions such as noise barriers, road structures, embankments, fields and landscaping (Perhomaa 2019)) and secondary in other earthwork activities. As soil material that can be utilised safely and systematically is not usually considered as waste, these kinds of activities can be also seen to prevent waste generation. Utilisation of soil in landfill structures or its disposal to landfill may be approved in accordance with the requirements of the Government Decree on Landfills 331/2013. In general, the final disposal can be justified only if soil material cannot be utilised for example due to its harmful components. Uncontaminated surplus landmasses that cannot be utilised in earthworks (e.g. silt and clay) can be disposed in the soil landfill site in accordance with the environmental permit of the site. (Ministry of the Environment 2015)

According to the Section 121, the waste holder shall draw up a shipping document on hazardous waste, contaminated soil and C&DW other than uncontaminated soil, that is shipped and delivered to a consignee as referred to in Section 29. In these cases, soil waste can generally be considered contaminated when its contamination level exceeds the lower reference value given in the Government Decree on the Assessment of Soil Contamination and Remediation Needs 214/2007 ("PIMA Decree"). (Ministry of the Environment 2015)

The revision of the Act is currently underway.

Land Use and Building Act 132/1999

The use of land areas and building activities conducted on them is regulated in the Land Use and Building Act. According to the Section 128 of the Act, actions that alter the landscape, such as earthworks or tree-felling require permit for landscape work in areas covered by a local detailed plan; a local detailed plan for shore areas, if the plan so stipulates; a local master plan, if the plan so stipulates; and in building prohibition areas (Section 53). In the area of local detailed plan, soil extraction may take place under a permit for landscape work, if it is necessary to remove soil from an individual construction site as a preparatory measure for a construction project requiring a building permit (Ympäristö.fi 2020). A building permit is needed for construction of permanent buildings or other structures requiring supervision (Section 125). A permit for landscape work is not required to extraction of land resources that require a permit referred to in the Land Extraction Act (555/1981). Neither is a permit required to carry out work that is in accordance with a granted building or action permit, or when the impact of action is minor (Section 128). An action permit is required for organization of a rather large separated storage or parking area or similar area, and for arrangements or alterations having significant

and long-term impacts on townscape or environmental scene (Section 126).

The mutual connection between land use planning and the utilisation of surplus landmasses is important, as land use planning has a decisive effect on the utilisation of surplus masses and enhancing their use. Via land use planning it is also possible to guide the material choices in construction and have an impact on resource efficiency, which can lead to reduced use of virgin materials and increase the use of recycled materials. (Sotejeff, 2019)

The deposition sites of surplus landmasses and their processing actions should promote the national land use guidelines and they need to be taken into account in the regional plan, local master plan, and local detailed plan (Koivuniemi, 2013). According to the Section 4 of the Land Use and Building Act, local master plans and local detailed plans must be drawn up in order to organize the land use and management in municipalities. In the local master plankomm the general principles of municipal land use are presented, whereas the purpose of the local detailed plan is to guide the use and building of land-areas within a municipality. The regional plans steer the municipal planning and consist of a general land use plan for the entire region or its specific sub-area for medium and long term. The major guidelines set in the regional planning cannot be deviated from in municipal planning (Koivuniemi, 2013).

Regional plans cannot be used for solving acute problems, but it has a significant impact on regional planning processes (Vaara, 2011). Deposition of surplus landmasses is often a regional issue to be solved, as they concern several municipalities. In these cases, the land use questions solved in the regional plans are critically important. (Ministry of the Environment, 2001, cited by Koivuniemi, 2013). For example, in the new Helsinki-Uusimaa Land Use Plan 2050 prepared by Helsinki-Uusimaa Regional Council (2020) development areas for landmass management are separately pointed out. In a phase of more detailed planning excavation, treatment and storing of soils; deposition of unpolluted surplus landmasses; and activities related to circular economy can be situated in these areas. (Helsinki-Uusimaa Regional Council, 2020) The sites for treatment and disposal of surplus landmasses must adapt to the local master plan of the area. The area required for operation and the main use of the area after the operation has ceased are defined in the local master plan. The placement of the area must not hamper the implementation of the local master plan or the local detailed plan. Drawing up a local detailed plan is usually justified when planning the establishment of the soil reception area. This should be done at least in the cases when the area is in connection with another area subjected to local detailed plan, or when the after use of the area requires local detailed planning (Kautto & Lepola, 2005). It is a common practise to start looking for suitable sites for surplus landmass deposition and storing from areas that are not subjected to local detailed planning, an industrial area, or an area for recreational use (Koivuniemi, 2013).

The revision of the Act is currently underway, see Section 4.1. for more information.

Act on Environmental Impact Assessment Procedure 252/2017

The Environmental Impact Assessment Procedure (EIA) is applied to projects that

may have significant adverse environmental impacts (Section 3). Regarding to the projects related to treatment of surplus landmasses, EIA procedure should be applied to landfills for waste other than municipal waste or sludge that are designed for annual waste volume of at least 50 kt, and for physico-chemical waste treatment plants with a volume exceeding 100 t per day. The physico-chemical treatment of waste within the meaning of the EIA Act covers any physical or chemical treatment activity (Ministry of the Environment, 2015).

Environmental Protection Act 527/2014

Environmental Protection Act and Decree determine when an activity requires an environmental permit. The Act is applied to activities that may cause or cause environmental pollution or generate waste and to waste treatment (Section 2). Activities subject to permit include professional treatment of soil waste or its treatment at an installation (Section 27 and Appendix 1 (tables 1 & 2, part 13)). The Act does not set a lower limit for professional treatment nor treatment at an installation. Therefore, an activity that is professional or institutional by its nature or scale requires an environmental permit, whereas minor utilization of soil waste or other small-scale treatment activity does not require a permit. (Ministry of the Environment, 2015)

Typical activities requiring environmental permit include:

- Treatment of contaminated soils (excl. treatment and utilization in the excavation area on the basis of the decision given in Section 136)
- A soil treatment site (i.e. a place that is used as a temporary storage and a (mechanical) sorting center for surplus soils)
- A soil landfill site
- Utilization of soil wastes in landfill structures or their disposal in landfill
- A long-term storage of soil prior to utilization or treatment; or
- Physical, chemical or biological treatment of soils aiming to change the chemical properties or other waste properties of the material. (Ministry of the Environment 2015)

Intermediate storage prior to utilisation may also be accepted in the environmental permit concerning the utilization of soil waste in case the storage is located in the same sphere of operations. If the storage is located elsewhere, a separate permit is required. (Ministry of the Environment 2015)

In addition, treatment of soils requires an environmental permit on the basis of the following criteria pursuant to Section 27, even though the soil materials in question would not be considered as waste:

- If an activity may cause water pollution and the permit under the Water Act (587/2011) is not required
- If conveying of wastewater may cause the pollution of a ditch, spring, or streamlet
- If an activity may cause an unreasonable burden on the surroundings according to the Adjoining Properties Act (26/1920) (Section 17, subsection 1).

Operational drawbacks may cause for example dust or noise, and discharge of

seepage and storm water. Regarding to these, the need for permit must always be considered case by case depending on the nature and location of the activity. (Ministry of the Environment 2015)

Crushing of rock requires an environmental permit if the crushing plant is fixed, or if the mobile plant is in a certain area and the crushing lasts for at least 50 days in total (Section 27 and Appendix 1 (table 2, part 7, subsection e)).

An environmental permit for the treatment of contaminated soil must consider the requirements concerning persistent organic pollutants (POPs) laid down in the Decree (EU 2019/1021).

The storage and crushing of unpolluted blasted or quarried rock from earth and road construction sites that is brought to rock treatment centres does not normally require an environmental permit, as the material in question is not classified as waste. The production of topsoil from unpolluted arable soil, excavated from construction site, in such way that the soil is only mechanically treated and utilised immediately or after a short storage period (usually less than one year), is not considered waste treatment and does not require an environmental permit. In cases where masses originated from construction activities are planned to be used in large amounts to change the height ratios of the arable land and to improve the growing conditions, the need for environmental permit must be decided case by case basis. (Ministry of the Environment, 2015)

See Section 4.1. for more information.

Waste Tax Act 1126/2010

Waste tax is levied on waste deposited at landfills. Sites where only materials originating from soil or bedrock are deposited or where waste is utilised are not subject to waste tax. Nor does it apply to an area where waste is stored separately from other wastes for less than three years prior to its treatment or utilisation. Similarly, the Act does not apply to hazardous wastes, nor wastes that are utilised in landfill structures. If soil waste is deposited to landfill requiring an environmental permit, the tax will be levied.

The Ministry of the Environment has recently published a report concerning the taxation of the waste disposed to landfill (Laine-Ylijoki et al., 2020). The results showed that in addition to the increase in the landfill tax, the tax base should be broadened to include more waste codes or all waste in the waste list. The taxation of soil wastes from construction and demolition (EWC category 17 05) was also assessed. It was estimated that the taxation would not generate specific negative environmental impacts regarding to management of these wastes, excluding a possible increase on the amount of waste diverted to soil landfill sites, especially as most of these wastes are currently disposed to landfill due to their exemption from taxation. Consequently, in the short-term tax liability could also increase a pressure on quasi-utilization at least in the landfills. On the other hand, the taxation would support the development regarding to the regional management of landmasses that has already begun.

Government Decree on the Assessment of Soil Contamination and Remediation Needs 214/2007 ("PIMA Decree")

Government Decree 214/2007 guides the assessment of soil contamination and remediation needs. The threshold and guideline values for common harmful substances in soil are given in Appendix of the Decree. According to the Section 2, the soil contamination and remediation needs are based on an assessment of the hazard to health or the environment. The assessment is made on a risk basis, so it must be made if the concentration of harmful substances exceeds the values prescribed in the Appendix, or if the site is presumed to be polluted for example if it has been used as an industrial or storage area. Contamination is determined by sampling and they must be based on standardized methods (Halttunen, 2020).

Government Decree on Landfills 331/2013

The deposition of soil waste to a landfill other than soil landfill is regulated in the Government Decree on Landfills 331/2013. In the Decree, general restrictions on the acceptance of waste at a landfill (Sections 13–15) and assessment procedure for acceptance at a landfill (Sections 16–23) are provided. According to the restrictions, waste can only be disposed accordingly to their classification if no exception mentioned (hazardous, non-hazardous, and inert waste). In addition, the Decree restricts the acceptance of non-hazardous waste containing biodegradable and other organic matter into landfills from 1 January 2016. However, this restriction does not apply to a contaminated soil or contaminated dredging waste deposited separately from other waste (Section 28). For waste containing Persistent Organic Pollutants (POP), the Government Decree refers to the POP regulation (Regulation (EU) No 2019/1021 of the European Parliament and of the Council on persistent organic pollutants) that sets a ban on landfilling of waste containing POP compounds above certain limit values. In order to determine the suitability of soil waste for landfill, it must be determined, among other things, whether the soil in question is classified as hazardous or non-hazardous. Some of the non-hazardous waste can be classified as inert, depending on its characteristics. (Ministry of the Environment 2015)

A2.4.2 Risk assessment

Specific activities on a certain site, such as land use change or excavation or construction works, can trigger the need to investigate the contamination of land (Ministry of Environment, 2014). The Finnish authorities have developed and improved several policy and legislative instruments to promote sustainable contaminated land management practises (Reinikainen & Sorvari, 2016). The different policy instruments are shortly described in in this section.

Related to risk assessment, the decision-making and actions taken are guided by legislation. The most important ones are the Environmental Protection Act and the Decree on Assessment of Soil Contamination and Remediation Needs, i.e. so-called PIMA Decree. The Environmental Protection Act indicates the need for a site-specific risk assessment but is rather non-specific. The PIMA Decree was prepared to specify these generic provisions and it provides a framed procedure for performing site-

specific risk assessments. Three categories of risk-based soil screening values for 52 substances are presented in the Decree. A risk assessment is mandatory if the concentration of one or more harmful substances exceeds the threshold value. It also defines uncontaminated soil, alongside the background concentration if it is higher than the threshold value. The guideline values mean that in industrial or storage areas etc., soil can be regarded as contaminated, if the concentration of one or several substances exceeds the upper guideline value, and in other areas soil can be regarded as contaminated if the concentration exceeds the lower guideline value. (Reinikainen & Sorvari, 2016). The guideline values, however, are not legally binding decision benchmarks, which means that the actual site-specific assessment is prioritized over the generic values (Reinikainen, 2021).

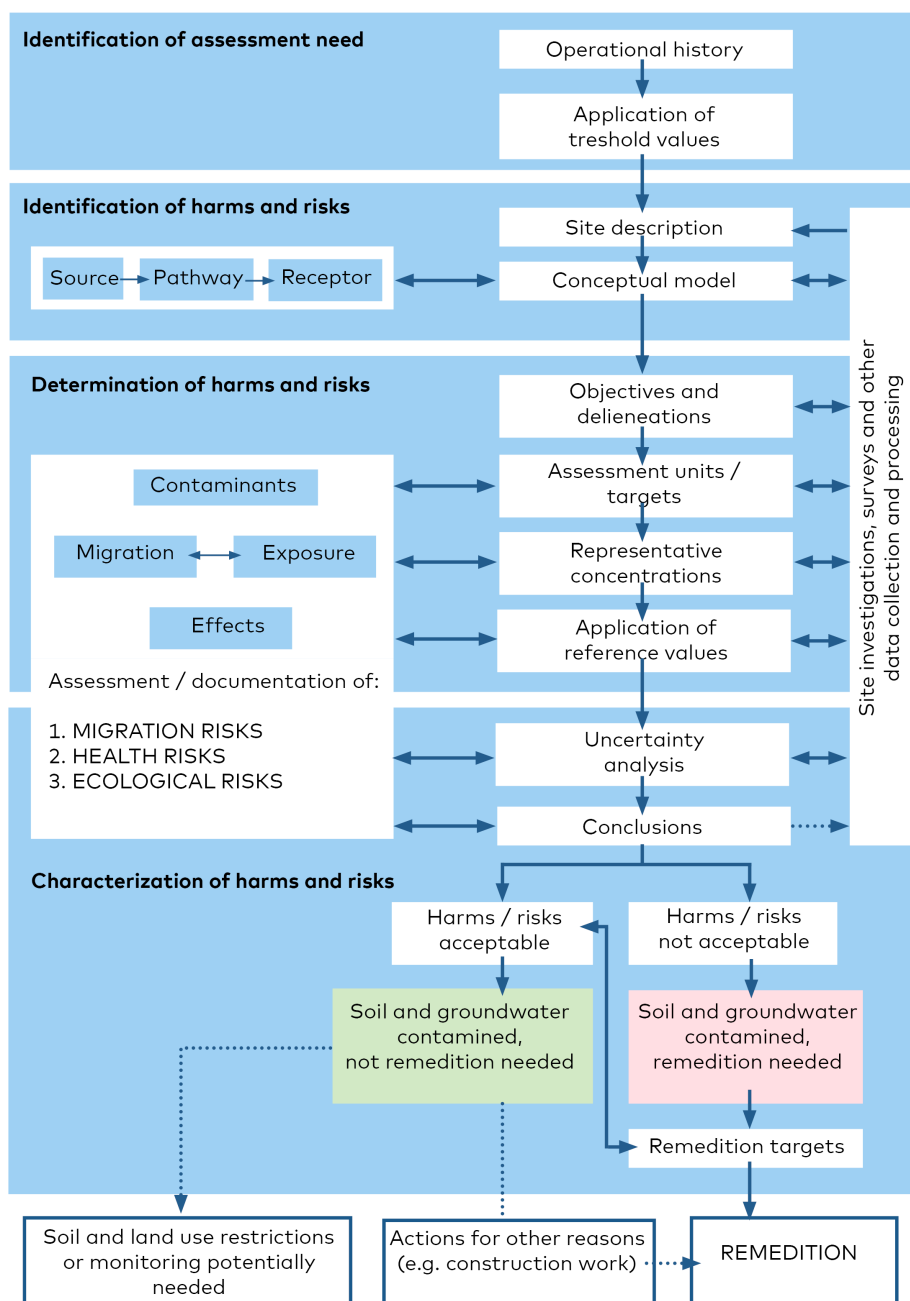
Basically, the PIMA Decree describes the elements that have to be taken into account in the assessment but does not explain its actual implementation. Therefore, a guideline was published to promote justified risk-based decision making and to describe the different phases of the risk assessment procedure in practice (Figure 12). The methodology for risk assessment includes three basic steps: risk identification, risk determination, and risk characterization. The risk assessment should always be site-specific, and the level of implementation chosen based on the site in question, targets of the assessment, data and resources availability, intricacy of the issue, and the requirements of decision-makers (Reinikainen & Sorvari, 2016).

The threshold values given for non-polluted soils are rather low and often exceeded. Further guidance is needed on values to be used in risk assessments for small cases (i.e. not huge soil amounts to be managed in urban environments already polluted to some extent) with limited resources to conduct a detailed risk assessment. Information on suitability of field analysators for different pollutants is needed in the field (e.g. applicability, required detection limits, lessons learned).

Currently, more than 90% of the risk assessments and remediation targets made for the purpose of remediation of contaminated sites are based on the screening values of the PIMA Decree (YTF, 2016) despite the fact that the values are not legally binding cut-off criteria for site remediation (Reinikainen, 2021).

Figure 12 A procedure for risk assessment (Reinikainen & Sorvari, 2016).

RISK ASSESSMENT



National risk management strategy for contaminated land in Finland ("PIMA" strategy) (2014–2015) and National Investigation and Remediation Programme for Contaminated Sites (2016–2018)

The aim was to generate a national understanding and targets concerning the organisation of the risk management of contaminated areas. The main goal is that by 2040 both the health and environmental risks posed by contaminated areas have been managed in a sustainable way. The following objectives should be met to

achieve this goal (Ministry of the Environment 2017):

- Identification, investigation and systematic remediation of risk sites
- Land use and risk management in contaminated areas support each other to obtain sustainable overall solutions
- Data systems support user-driven planning and decision-making
- Cost-efficient rehabilitation methods conserve natural resources, minimise harmful environmental impacts and promote circular economy
- Interactive procedures and clear distribution of labour, obligations and responsibilities of the actors
- Open, transparent and interactive activity and communication. (Ministry of the Environment 2017)

The strategy includes the *National Investigation and Remediation Programme for Contaminated Sites* that aims to identify notable contaminated areas, promote their investigation, and carry out necessary risk management actions (Ministry of the Environment 2017).

Risk assessment and sustainable risk management of contaminated land

A national guideline is given to describe the assessment of contaminated soil and remediation needs, in accordance with the Government Decree on the Assessment of Soil Contamination and Remediation Needs ("PIMA" Decree). The objectives, implementation and documentation of risk assessment are considered in the guideline, together with the assessment and principles of sustainable risk management. In addition, general recommendations concerning the above are given. The guideline needs to be applied suitably to the case in question in terms of content, scope and methods used. The guides are not binding. (Ministry of Environment 2014)

Sustainable risk management practices of contaminated land

The aim of the project was to promote the introduction of sustainable risk management solutions and operating models for the circular economy in the sector of management of contaminated lands. The methods of sustainability assessment of the risk management were investigated, and its assessment methods were tested. Together with the stakeholders policy instruments were identified to steer the decision making and operational practice concerning contaminated lands towards sustainable circular economy. As a result, five policy instruments concerning operations model and regulations for sustainable risk management, landfill disposal, soil state database, public procurement procedures, and spatial planning were recommended for further inspections. (Pyy et al. 2017)

Acid sulphate soils in circular economy projects: Case Vällimaa and Matalahti

The prediction of the occurrence of acid sulphate soils, and research methods suitable for their investigation are presented in the report. In addition, some first stage risk management actions for minimising the adverse environmental impacts of acid sulphate soils are presented. (Auri et al. 2020)

A2.4.3 Relevant reports and guidance

- **A review of potential economic instruments for circular economy** by Tikkanen et al. (2018) proposes duty on soils (to virgin materials) to enhance recycling of soils and improve price competitiveness of recycled materials. In addition, the possibilities of introducing a duty on soils were investigated in a report by Ministry of Finance already in 2012 (*Maa-ainesvero - Selvitys maa-aineveron käyttöönnoton mahdollisuuksista ja tarkoituksenmukaisuudesta*)
- **Kiviaineshuollon kehittäminen (Utveckling av hanteringen av stenmaterial)** (Huhtinen et al. 2018) In the report, a preliminary operations model for management of stony materials is presented. Resource wise aggregate service requires well-functioning mass coordination, the removal of barriers for utilisation, and improving the acceptability of aggregate management.
- **Kaivetut maa-ainekset – Jäteluonne ja käsittely (Excavated soils – Waste status and management)** (Ministry of Environment, memorandum 3.7.2015) ("Maa-ainesmuistio"). The aim is to clarify the interpretations regarding to soil materials and soil wastes given in Waste Act and Environmental Protection Act. Classification of soils generated in construction (are materials regarded as waste or non-waste), requirements for their treatment and administrative procedures to be followed are presented.

A2.4.4 Municipal strategies

The regional optimization of the landmass use is proceeding rapidly, with the aim of minimizing transports and emissions, and to achieve the underlying national, regional, and municipal carbon neutrality targets (Laine-Ylijoki et al. 2020). At least Helsinki, Espoo, Vantaa, Tampere, Hämeenlinna, and Turku have employed a landmass coordinator, and several action and development programs as well as projects for better utilization of surplus masses are ongoing. Some examples of municipal activities are listed below:

- **City of Helsinki.** [Development program for utilization of excavated landmasses 2014–2017](#). A new development program "[The Principles for the Use of Land Masses, Rocks and Demolition Materials in Groundworks](#)" started in 2019. See Section 3.4 for more information.
- **City of Hämeenlinna.** Objectives for soil management in Hämeenlinna were developed as a part of research project in 2016–2019 aiming to develop recycling of soils. These objectives are now implemented in practice, e.g. via several pilot projects regarding to landmass utilisation. (CircWaste 2020) See Section 3.4 for more information.
- **City of Oulu.** A development project for soil use to promote circular economy in infra construction 2016-2017.
- **City of Tampere.** A soil management program to develop and enhance the use of surplus soils and recycled materials, accepted in February 2021. The program aims to save natural resources, reduce emissions caused by infrastructure construction, and decrease the costs of construction.
- **City of Espoo.** An action program for soil and rock management and recovered materials in groundworks, 2018–2021.
- **Regional council of Southwest Finland.** A project for utilisation of surplus landmasses and recycled materials in Southwest Finland.

A2.4.5 Marketplaces

Some regions in Finland have commercial digital marketplaces on the internet for transmitting soils between the construction sites and facilitating the preparation of shipping documents. Sufficient supply and demand are requirements for a functioning marketplace; this condition is currently being fulfilled mainly in growing urban areas. (Huhtinen 2018) In addition, some national marketplaces also exist:

- [Maapörssi](#). Maapörssi is a Finnish digital platform for land builders established for sharing of reusable soil and demolition materials. The service offers significantly reduced building expenses: instead of paying a high price for "new" soil, Maapörssi users can receive excess soils mined in other construction sites, resulting in a more efficient use of resources. The aim is also to minimize the transport distances, and thus reduce emissions from the transport. The service includes a transport application that helps customer companies manage their material flows and contains features such as real time digital consignment reports. The platform was launched in 2006 as an advertisement website and has since been developed into a digital tool for handling of excess soils and demolition materials. New features are under development. To date, soils and demolition materials have been recycled using Maapörssi in around 3000–4000 construction site projects in southern parts of Finland. In connection to Maapörssi, an application called "MaaApp" provides real-time information on transports.
- [Materiaalitori](#). Platform for professional exchange of wastes and side streams for companies and organisations.

About this publication

Survey of the emergence and use of naturally occurring materials

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