SKB TECHNICAL REPORT

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Feasibility study for siting of a deep repository within the Storuman municipality

Swedish Nuclear Fuel and Waste Management Co

January 1995

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FEASIBILITY STUDY FOR SITING OF A DEEP REPOSITORY WITHIN THE STORUMAN MUNICIPALITY

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Key words: Deep repository, site selection, feasibility study, Storuman

FOREWORD

This report summarizes the results of the feasibility study in Storuman. It also contains SKB's collective evaluation of the results (Chapter 11). A status report was published in June 1994. The purpose of the status report was to give the municipality, its reference group and other interested groups in Storuman and in the region, a basis for discussion and opinions before the final report was written. Numerous viewpoints have been presented and have occasioned some supplementary studies or adjustments and additions to the final report. The viewpoints of the reference group on the status report are compiled in an appendix to this final report.

For SKB's part, this report represents the conclusion of the feasibility study. As is evident from the viewpoints of the reference group, there are important questions that have not been fully answered within the framework of the feasibility study. Answering some of these questions requires information that can only be provided by a site investigation. Other questions of a more general nature can be taken up if the final evaluation of the feasibility study results in a common interest to continue site investigations in Storuman. The municipality's planned independent review may also identify questions that should be further examined before a decision can be made on a possible continuation. Proposals for such additional studies must be discussed between SKB and Storuman Municipality. In conjunction with the independent review, SKB is prepared to provide additional data if required, as well as clarifications of SKB's attitude and viewpoints.

The feasibility study in Storuman is the first of its kind. Similar feasibility studies are planned for 5-10 municipalities. For SKB's part, this first feasibility study has provided valuable experience for the siting work. SKB would like to thank all those who have, in different ways and from different points of departure, contributed to the execution of the feasibility study.

Stockholm, January 1995

SWEDISH NUCLEAR FUEL AND WASTE MANAGEMENT CO

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GENERAL BACKGROUND

A deep repository differs from other industrial activities and other underground facilities in one essential respect: The facility is intended for the handling and disposal of materials with a high concentration of radioactive materials. This leads to special requirements on quality and safety, and consequently the foremost reason why the facility and its siting arouse discussion.

To understand both the potential for safe handling and disposal and the potential risks associated with the waste, it is necessary to be aware of certain fundamental facts regarding the properties of the waste and the radiation emitted. The properties of the nuclear waste and the protective measures that are employed are described in concise and fundamental terms below.

RADIOACTIVITY

Radioactive materials (radionuclides) can be dangerous in two ways:

- They emit radiation (mainly gamma radiation) that can harm humans. This is protected against by surrounding the radioactive waste with sufficiently thick radiation shields that absorb the radiation. Extensive experience of such protective measures has been gained from work at nuclear power plants and within medical applications.
- They could conceivably get into the air or water and in this way reach man and enter the human body. This is protected against by making sure that the waste is in a solid form that makes it difficult or impossible for it to be vaporized in air or dissolved in water. In addition, the waste is surrounded by several barriers – e.g. canister, clay and rock – that prevent it from coming into any kind of contact with the human environment.

HIGH-LEVEL RADIOACTIVE WASTE

The spent nuclear fuel comes to the deep repository encapsulated in canisters of steel and copper, see Appendix 1. The radioactive materials are contained (entrapped) in the nuclear fuel, a ceramic material. The canister provides a hermetic enclosure which prevents the radioactive substances in the fuel from coming into contact with the environment. The canister also attenuates the gamma radiation emitted by the fuel. An outer radiation shield is required during shipment and handling of the canisters. This is achieved by placing the canisters inside transport casks with steel walls up to two decimetres thick.

When the canisters have been placed in the deep repository, all radiation is attenuated by the canister, the surrounding clay and the rock around the deposition holes so that the radiation level beyond one to two metres from each canister is not elevated above the natural background radiation level. There is therefore no way for radiation or radioactive materials to reach the environment and people on the ground surface directly. In other words, the deep repository is designed to prevent any radioactive release whatsoever (zero release). Thorough studies are made in the safety assessments of whether, and how, the different protective barriers can be damaged, and what consequences this would have. A fundamental principle – the multibarrier principle – is that safety shall not be dependent solely on one barrier, but that each of the barriers (the waste form, the canister, the clay, the rock) shall in itself be an effective obstacle against the escape of any radioactive radionuclides.

In a canister containing spent nuclear fuel, there is no generation of energy of the kind that is generated in a nuclear power plant. Nor is it physically possible for the fuel to be melted by heat or explode. Heat output in nuclear fuel at different times is illustrated in the table below. Heat in the spent fuel (decay heat) is generated by the disintegration (decay) of the radionuclides.

Table 1. Heat output in nuclear fuel at different times.

Time	Heat output (kW/t fuel)
During reactor operation	25,000
After reactor shutdown	1,500
During transport to interim storage (after 1 year)	10
During transport to deep repository (after about 40 years)	1

PURPOSE OF THE DEEP REPOSITORY

In general, it can be concluded that the handling of encapsulated spent nuclear fuel at a deep repository is simpler than the handling of non-encapsulated fuel that takes place today at the nuclear power plants and the interim storage facility, CLAB. Total activity content and radiation are much lower and the waste is better protected due to the fact that it is encapsulated. Nevertheless, the encapsulated fuel still contains large quantities of radionuclides, some of which are long-lived. This is the reason why it is necessary to arrange safe containment and isolation of the spent fuel from the living biosphere. Supervised storage, such as takes place in CLAB, is an effective method for interim (temporary) storage, but it is not a permanent solution, since if surveillance is suspended or relaxed, man and the environment still need to be protected. Swedish law therefore requires final disposal, which is why Sweden, along with other countries, is working to bring about final disposal in deep geological formations (deep repositories).

WASTE QUANTITIES

Altogether, it is estimated that the Swedish nuclear power programme up to 2010 will have produced some 8,000 tonnes of spent nuclear fuel. This waste will be encapsulated in approximately 4,500 copper/steel canisters, which will be emplaced (deposited) in the deep repository. Besides spent fuel, approximately 20,000 m^3 of other long-lived waste will be deposited in the deep repository.

The deep repository will be constructed in two stages. Approximately 400 canisters of spent fuel will be deposited in the first stage. It is estimated that this initial operating period will start not earlier than 2008 and continue for roughly 5 years, after which the experience gained from this stage will be evaluated by SKB and the regulatory authorities. If the verdict is favourable, the rest of the repository will be built (stage 2).

The largest quantities of waste from the nuclear power plants and other nuclear facilities consist of operational and decommissioning waste. The total volume is estimated at 190,000 m^3. This waste is planned to be emplaced in the Final Repository for Radioactive Operational Waste (SFR) in Forsmark.

ABBREVIATIONS

The Swedish Nuclear Fuel and Waste Management Company, SKB, is responsible for the management and disposal of Sweden's radioactive waste. The primary category is waste from the nuclear power plants, but radioactive waste is also produced by hospitals, industry and research institutions. SKB was formed jointly by the power utilities that produce nuclear energy in Sweden.

The Swedish Nuclear Power Inspectorate, SKI, and the Swedish Radiation Protection Institute, SSI, are the public authorities who scrutinize the activities of SKB and oversee safety both in the operation of the nuclear power plants and in waste management. SKI also administers fees charged on the production of nuclear-generated electricity that are intended to finance the management and disposal of the nuclear waste. Besides these two authorities, there is a scientific council, KASAM (the National Council for Nuclear Waste). KASAM is associated with the Ministry of the Environment and has been given the task of submitting a report to the Government every third year with its independent assessment of the state of knowledge in the nuclear waste field.

Numerous references are made in this report to CLAB, SFR and the Äspö HRL, which are facilities operated by SKB, and the Ship M/S Sigyn; all are included in the Swedish system for management of the waste from nuclear power.

CLAB (Central Interim Storage Facility for Spent Nuclear Fuel) is situated at the Oskarshamn Nuclear Power Plant. There the spent nuclear fuel is stored for 30-40 years. During this time its radioactivity and heat output decline by 90%, facilitating encapsulation, transport and handling of the fuel at the deep repository. Storage and handling of the spent fuel at CLAB take place under water in pools.

SFR (Final Repository for Radioactive Operational Waste) is located beneath the seabed outside the Forsmark Nuclear Power Plant. All the low- and intermediate-level short-lived waste from the operation of the nuclear power plants will be disposed of in SFR. The disposal chambers are situated in rock caverns 60 m below the floor of the sea.

The Äspö HRL (Hard Rock Laboratory) is an underground laboratory built in solid rock. It is situated in the vicinity of the Oskarshamn Nuclear Power Plant and consists of an access tunnel down to a depth of about 450 m. Different methods for site investigation and detailed characterization, as well as technology for final disposal of the spent fuel, are being tested.

The M/S Sigyn is used for all sea shipments of spent nuclear fuel and other radioactive waste. She is specially built for these shipments and normally makes 30-40 trips a year between the nuclear power plants and CLAB or SFR.

SUMMARY

It is SKB's task to gather a broad body of information for the siting of a deep repository for Sweden's spent nuclear fuel and other long-lived radioactive waste. The criteria presented by SKB serve as guidelines for the siting studies. The most important consideration is that the safety requirements can be met on the site where the deep repository is built. Other siting factors are concerned with technology, land and environment plus societal aspects.

Overviews of siting factors are compiled in **general siting studies** of all or parts of Sweden. **Feasibility studies** examine the siting prospects in potentially suitable and interested municipalities. SKB plans to carry out feasibility studies in five to ten municipalities in different parts of the country. General studies and feasibility studies are primarily based on existing material. They result in the identification of land areas within the studied municipalities that may be suitable for further investigations. A selection will be made among these areas and site investigations will be conducted on at least two sites in the country.

The feasibility study in Storuman is the first to be conducted. It begun during the second half of 1993 with the conclusion of an agreement between the municipality and SKB. SKB has been in charge of the execution of the feasibility study. The municipality has had insight into and been able to influence the feasibility study through a steering group with two representatives for the municipality and two for SKB. A municipal coordinator has been responsible for the municipality's activities in conjunction with the feasibility study. A reference group with 24 members appointed by political parties, involving the County Administrative Board, the Swedish Association of Local Authorities and non-governmental organizations in the municipality, has had the task of following the work and contributing opinions and ideas. Experts from the geological survey, universities and consulting firms have been engaged to carry out fact gatherings and analyses. They are solely responsible for the factual contents and conclusions of their investigations. SKB has been responsible for the summary provided in a status report published in June 1994, as well as for the conclusions and evaluations in this final report.

Altogether about 30 reports have been published within the framework of the feasibility study. The purpose of the various studies have been to describe, in as much detail as possible, the prospects for siting a deep repository in the municipality of Storuman, and to shed light on the possible positive and negative consequences of such a siting.

The feasibility study has led to a discussion within the municipality and the region concerning the siting of a deep repository. In SKB's opinion, this gives all those concerned ample opportunity to become acquainted with the issues and to assert their interests and present their viewpoints at an early stage.

The results of the feasibility study in Storuman are summarized in the form of answers to and comments on the following questions:

- Do prospects exist for siting a deep repository in Storuman Municipality?
- What are the consequences (positive and negative) of a deep repository?
- Will the siting studies in Storuman continue?

DO PROSPECTS EXIST FOR SITING A DEEP REPOSITORY WITHIN THE STORUMAN MUNICIPALITY?

The feasibility study shows that areas exist within Storuman Municipality which may offer good prospects for the siting of a deep repository. However, a more detailed assessment of long-term safety requires comprehensive geoscientific investigations and a safety assessment.

The top-priority area for any further studies is Joran. This area is about 90 km^2 in size, the rock is well-exposed and consists entirely of granite. Available data indicate that the granite is homogeneous, with a low fracture content (fracture-poor) and relatively few fracture zones. Due to the size of the area it should be possible to locate the facility with a connecting railway and road so that allowance is made for both the suitability of the bedrock conditions and the interests of landowners, nearby residents, reindeer herders and others. Factors that must be given particular attention in further investigations are the depth of the granite and the possible presence of flat-lying fracture zones, elevated rock stresses and radon emission.

An area of secondary interest for further studies is Lumsen, especially the part around Lycksaliden. Here as well there are presumably large volumes of homogeneous and fracture-poor granite. The degree of exposure is low, however, and the area is smaller than Joran.

There are railways and roads of good standard close to both Joran and Lumsen that can be utilized for shipments to a deep repository. The shipments could, for example, go by rail from Skelleftehamn harbour or Umeå outer harbour to a deep repository in Storuman. Road shipments are also possible, but have certain limitations today and will probably have in the future as well.

WHAT ARE THE POSITIVE AND NEGATIVE CONSEQUENCES OF A DEEP REPOSITORY?

Deciding what are positive versus negative consequences of a deep repository is to some extent a question of opinions and values. In simplified terms, it might be said that there are two opposing ways of looking at the deep repository:

- In one perspective, the deep repository is an environmental facility of national importance in which nuclear waste is isolated in order to protect people in the future. It is based on long-range planning and stringent quality standards, provides good jobs with advanced technology, arouses interest both in Sweden and internationally and will contribute in a positive way to the economy and social life of the municipality and the region.
- In another perspective, the deep repository is a dumping site for atomic garbage and a threat to the environment both now and in the future. It arouses anxiety among the population and will frighten off tourists and visitors.

To shed light on all aspects, the feasibility study has therefore not been limited to geoscientific and technical questions, but has included several enquiries into such aspects as tourism, the future outlook for the municipality, business opportunities and the local economy. This material includes both facts and analyses, as well as the opinions of entrepreneurs and local citizens with different perspectives on the question.

Consequences for external environment, working environment and safety

Like any other major industrial facility, the deep repository entails some environmental impact on the site where it is constructed. The feasibility study's environmental study finds that the impact is small compared with what is usual in industrial contexts. This is because there is no real industrial process and chemicals are used sparingly. Aside from the encapsulated wastes, the quantity of polluting substances is small. During site investigations, construction and operation of the facility, some groundwater drawdown can take place on the site just as in mines. The most tangible environmental impact may be the dumps of rock waste and the impact caused by the construction of a railway or road to the repository site. Rock waste should therefore be reused to as great an extent as possible. The placement of the facility and railway/road in the terrain must be done so that the impact on the environment, outdoor recreation activities, hunting, fishing and reindeer herding is small.

The working environment at a deep repository shall conform to a high standard. Mining experience shows that rock excavation work under ground is associated with risks of work-related injuries. Handling of rock waste and shipments of heavy cargoes can also entail risks of occupational injuries. Work routines and technical aspects must therefore be designed to minimize such risks.

The radiological working environment will conform to the standards and requirements that apply to nuclear facilities. Based on experience gained on the M/S Sigyn and at CLAB and SFR, shipments and handling at the deep repository can be designed so that personnel doses are kept well below existing safety limits. Granites with higher uranium concentrations than usual in Storuman can give rise to high radon concentrations in rock facilities. In a deep repository, the radon must be ventilated away so that levels can be kept under legal limits. In other respects, the working environment at the deep repository can be compared with the working environment at factories and offices.

Transport safety will be ensured through a system of transport planning, protective transport casks, physical protection and emergency planning. The radioactive waste is in solid form and completely enclosed in canisters which are in turn contained in transport casks with steel walls up to 2 decimetres thick. The casks protect the waste in the event of an accident and shield off the radiation. Good experience exists with shipments of this type, which have been made by rail and road for the past 25 years in other countries. The shipments to the deep repository are not expected to entail any risks other than those that are usually associated with shipments of heavy goods.

The design of the deep repository and all measures on conjunction with deposition are aimed at containing and isolating all radioactive material. A central part of an environmental impact assessment for the deep repository is the assessment of long-term radiological safety. The feasibility study does not include any such assessment of safety for a deep repository in Storuman, since this requires, among other things, borehole investigations, which cannot be done until a site investigation is undertaken. The question of the long-term safety of a final repository has previously been examined by both SKB and the regulatory authorities by means of safety assessments. Similar assessments have also been carried out abroad. The results show that if the bedrock, the canister and the backfill materials fulfil certain requirements, disposal can take place in a safe manner.

Consequences for the local citizens, business and industry, tourism and the local economy

The establishment and operation of a deep repository will affect the locality and the region in different ways. The deep repository entails jobs, an increase in population, support for the local infrastructure and new business opportunities for the local entrepreneurs. However, it also entails something unknown and new that can be perceived as a threat and create anxiety. Politically and in terms of public opinion, siting of the deep repository is a sensitive issue. Experience both in Sweden and in other countries shows that strong feelings and opinions can be aroused.

There are no ready-made answers to what the consequences might be for the municipality of Storuman if the deep repository were sited there. The feasibility study's surveys in this area have therefore aimed at gathering fundamental background data on the municipality, the deep repository and development expectations under different premises, and at shedding light on some central questions (particularly tourism) from different perspectives.

Storuman is a sparsely populated municipality in the interior of Norrland (the northern territory of Sweden) with vast open spaces. It has been experiencing considerable problems with unemployment and depopulation for several decades. The labour market is stagnant in the basic economic sectors of agriculture and forestry, including wood-processing and hydropower. An exception is the mountainous areas around Tärnaby and Hemavan in the western part of the municipality, where the growth of the tourist industry has enabled the population to remain relatively stable through the years.

A deep repository in the eastern forested part of the municipality would, when fully operational, provide about 200 direct and 100 or more indirect jobs, which would correspond to nearly 10% of the number of persons employed in the municipality today. Nearly 500 more persons would live in the municipality between the years 2000 and 2050 with a deep repository than without one, according to a forecast by researchers at Umeå University. The same study estimates that more than 30% or about SEK 5 billion of the total cost of SEK 15 billion could be absorbed locally. No alternative establishment of equivalent size or with equally long-range employment effects has been identified.

People in other municipalities in Västerbotten have expressed concern via the mass media and municipal council decisions for what a deep repository might mean for the region and have expressed their disapproval of shipments of radioactive waste through their municipality. A study has found that anxiety, and thereby reduced quality of life, is presumably unavoidable for certain groups in the community. A study of sitings of other controversial facilities shows that while opposition has been encountered, it has waned once the facility is built.

The question of what impact a deep repository might have on tourism has been examined in several surveys. Opinions are strongly divided, and it is really not possible to say with certainty on any objective grounds what the impact would be in reality. Many people, for example in the local tourist industry, believe that a deep repository would spoil the image of Lapland as virgin wilderness and thereby have a negative effect on tourism in the entire region. An expanding market for nature and wilderness tourism will be damaged, and German tourists, for example, would choose other areas instead.

Others maintain that a deep repository would, on the contrary, have positive effects for tourism and the travel industry. They point out that a deep repository of about 1 km^2 won't be noticed at all other than in its immediate vicinity. The establishment of the facility will also provide a better basis for an infrastructure (airline route, hotels, local services, etc.) which is also of benefit for tourism. A large number of technicians, research scientists, government officials, journalists and others, from both Sweden and other countries, will visit or work temporarily at the facility. Such visits and official travel already occur to SKB's existing facilities, and the volume of such travel for the deep repository will probably be at least as great as for these facilities. Finally, SKB notes that there does not appear to have been any negative impact on tourism at the existing facilities. The same question has also been discussed in other countries in connection with the siting of various nuclear waste facilities, but the actual outcome has not entailed any setback for tourism, in fact quite the opposite in some cases.

WILL THE SITING STUDIES IN STORUMAN CONTINUE?

A prerequisite for a continuation of the studies is that both SKB and the municipality are interested in going further. The municipality plans to have an independent review done of the feasibility study as a part of its preparation of the matter.

SKB's conclusion is that areas exist in the municipality that may offer good prospects. They will therefore be included in the siting material as being of potential interest for site investigations. On the other hand, SKB cannot specify today whether any particular area in Storuman should be selected for site investigation, since the results of the feasibility study in Storuman should be compared with the results of feasibility studies in other municipalities. This means that the studies in Storuman have now essentially been concluded in this phase. Certain supplementary information may, however, have to be gathered by SKB in connection with the municipality's independent review and any questions that thereby come up. Otherwise it will not be until results have been obtained from other feasibility studies that a continuation in Storuman can be considered for SKB's part. In conjunction with such a future site investigation, an environmental impact assessment (EIA) will have to be carried out. The nature of this work (the EIA process) should be established when these investigations are begun. In addition to the municipality, SKB and concerned authorities, an opportunity should also be given to e.g. municipalities who are affected by the shipments to participate in the EIA process. The native Sami people (Laplanders), landowners and nearby residents, as well as other local organizations, may also have interests to protect in conjunction with continued studies.

CONTENTS

1 INTRODUCTION

This chapter provides a brief overview of SKB's programme for the siting of Sweden's deep repository. The purpose of the feasibility study in Storuman is described, and the background to the decision to undertake a feasibility study in Storuman is given.

1.1 THE SITING WORK

The most important consideration for the siting of the deep repository is to choose a site where the safety-related conditions are very good. The siting strategy is furthermore based on the conviction that it is necessary and possible to find a site that meets stringent environmental and safety requirements at the same time as local acceptance for the establishment of the deep repository is sought. This approach is well in accord with the intentions behind applicable legislation in, for example, the Natural Resources Act (the Act on the Management of Natural Resources) and the Act on Nuclear Activities. The existing Swedish system with interim storage in CLAB also provides ample time and opportunity to consider the possibilities for siting a deep repository in cooperation with all involved parties.

The work of siting, construction and operation of the Swedish deep repository is taking place in stages, see Figure 1-1. A description of how the siting of a deep repository is planned to take place and what criteria apply to the selection of candidate sites is given in "RD&D-Programme 92 Supplement" /1-1/. Chapter 3 explains how these criteria have been applied in the feasibility study. A general description of SKB's planned system for encapsulation and deep disposal is given in Appendix 1.

The purpose of the siting work is to gather all the background information that is needed to select a site and to obtain permission to begin detailed characterization. This work proceeds in several stages:

General siting studies provide the general background and general conditions. They cover the entire country and major regions. A collective account is planned to be compiled during 1995, but a large part of the investigation material has already been published in different technical reports, see RD&D-Programme 92 Supplement, Appendix A /1-1/.

Feasibility studies examine the prospects for a deep repository in potentially suitable and interested municipalities. The existing and planned land-use as well as the environmental factors and the societal aspects are clarified relatively thoroughly in the feasibility studies. Judgements of siting factors for safety and technology are based on general knowledge and data. The feasibility study provides a basis for judging if and where areas with good potential exist in the municipality. Geoscientific conditions, transport aspects and impact on local business and industry and the local community are analyzed and described.

Site investigations are planned at a later stage for at least two sites in the country. They will be located in areas judged to be of particular interest on the basis of the feasibility studies and the general siting studies. A site investigation entails more extensive studies, including bedrock investigations in boreholes, and is estimated to take about three years. The safety-related and technical siting factors are clari-

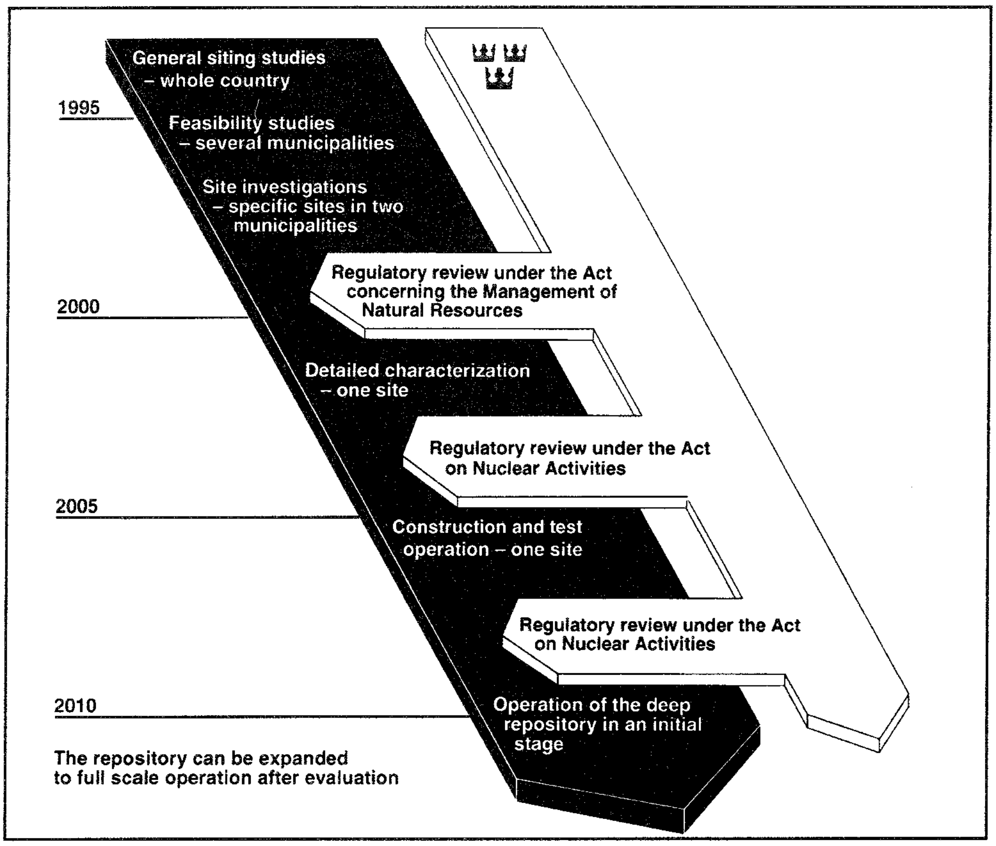


Figure 1-1. Different stages for siting, construction and commissioning of the deep repository.

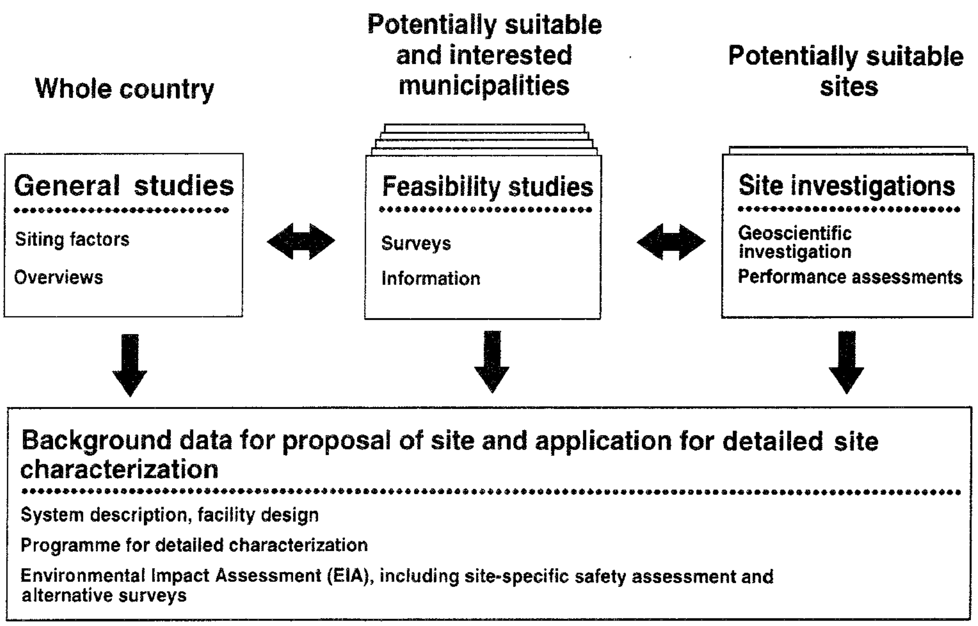


Figure 1-2. Main components in the siting work.

fied as far as possible. Some supplementary investigations of local land-use and environmental factors are also conducted.

Since information from repository depth is generally lacking in a feasibility study, the site investigation must start with an introductory phase aimed at answering questions that have emerged in the feasibility study and providing a general basis for verifying the suitability of the area or dismissing it from further studies. If these studies give positive results, complete site investigations are carried out. The results of these site investigations are compiled in an environmental impact assessment, which includes an assessment of long-term safety.

When at least two complete site investigations have been conducted, all relevant material from the siting work is compiled in an application under the Natural Resources Act for permission to carry out **detailed characterization** on one of the sites. The detailed characterization entails, among other things, a tunnel or a shaft down to the planned repository depth and determining the properties of the rock in detail.

A crucial consideration for site selection is that the safety requirements can be met. The background material for selection of a site for detailed characterization is therefore reviewed by the concerned authorities and relevant municipalities as a basis for the Government's decision. Figure 1-2 gives a schematic picture of the main components in the siting work.

The feasibility study in Storuman thus comprises a part of a comprehensive and step-by-step process of gathering information for the siting of a deep repository. SKB plans to carry out 5-10 feasibility studies at different locations in Sweden. Besides in Storuman, a feasibility study is currently (1994) under way in Malå Municipality.

1.2 THE PURPOSE OF A FEASIBILITY STUDY

The prospects for siting a deep repository within a municipality are examined in a feasibility study. The studies are based principally on existing material.

The following questions are dealt with:

- What are the general prospects for siting of a deep repository in the municipality?
- Within which parts of the municipality might there be suitable sites for a deep repository, considering geoscientific and societal aspects?
- How can the deep repository be designed with respect to local conditions?
- How can transportation be arranged?
- What are the important environmental and safety issues?
- What are the possible consequences (positive and negative) for the environment, the local economy, tourism and other enterprise within the municipality and the region?

SKB does not need any formal permits to carry out a feasibility study. However, in practice the feasibility studies are conducted in mutual understanding between SKB and the municipality in question.

A feasibility study is supposed to provide a broad body of facts as a basis for decisions by both the municipality and SKB. Both parties can then decide whether they are interested in conducting a site investigation. The same facts are made available to all involved parties, who thereby have an opportunity to present viewpoints long before any decisions need to be taken on the siting of the deep repository.

The purpose of the feasibility study is thus to investigate whether prospects exist for locating a deep repository in a particular municipality, and to gather data as a basis for a decision as to whether to proceed with continued investigations. Questions regarding the principles of final disposal, the advantages and disadvantages of the chosen concept, and the methods for evaluating long-term safety are dealt with in other contexts and are not investigated in the feasibility study.

1.3 THE DECISION TO UNDERTAKE A FEASIBILITY STUDY IN STORUMAN

In the beginning of November 1992, the municipality of Storuman invited SKB to furnish information on the prospects for a feasibility study in the municipality. The information was presented at a meeting on November 23rd with the municipal executive board. The invitation was the result of a letter which SKB had sent to all municipalities in Sweden in October 1992. The letter was occasioned by the attention received by SKB's RD&D-Programme 92 in the media, which led to questions from many municipalities and the public about future siting plans. The letter therefore contained general information on SKB's programme and the planned work involved with the siting of a deep repository. This led to various kinds of requests from a number of municipalities for further information from SKB. From those municipalities who wanted to initiate a discussion concerning the possibility of a feasibility study, SKB made an internal assessment of whether a feasibility study would be of interest from SKB's point of view. In the case of Storuman, this internal assessment was carried out during the period from November 1992 to January 1993. The following was then concluded:

- a large body of geoscientific data exists concerning the municipality;
- Storuman has large areas in its eastern part with crystalline rock of the type that could conceivably be suitable for a deep repository;
- parts of the crystalline rock in Storuman contain mineral deposits that should be avoided in the event a deep repository is built there;
- the municipality already has rock facilities (military, hydropower tunnels) and thereby experience of industrial underground construction;
- there are a number of suitable harbours along the coast of Västerbotten;
- there are good roads and railways to Storuman from the coast;
- good prospects should exist for avoiding land-use conflicts in view of the size of the potentially interesting bedrock in the municipality.

Based on these and other observations, SKB found that a feasibility study in Storuman would be of interest for SKB's part.

It took the municipality the first half of 1993 to arrive at a decision regarding the feasibility study. On June 29th, the municipal council resolved (with 24 in favour, 12 opposed, 5 abstaining) to conclude an agreement with SKB regarding a feasibility study. The most important events in the process leading up to this decision were:

January '93	Study trip to SKB's facilities in Forsmark (SFR) and Oskarshamn (CLAB, Äspö HRL) by representatives of political parties, local societies and interested groups as well as municipal officials.
Feb.–March '93	Circulation for comment of the question of a feasibility study to political parties, local societies and interested groups. 10 positive, 6 negative and 3 neutral answers were obtained.
April '93	Tabling of the question in the municipal council pending further information to the public.
May-June '93	5 public information meetings arranged by the municipality with participation of municipal representatives, SKB and authorities (SKI, SSI).
29 June '93	Decision on feasibility study in municipal council.

Ever since the question was raised at the end of 1992, an intensive debate has been carried on in the local and regional media. See further section 2.5, where the information activities and the public debate are described.

2 ORGANIZATION AND EXECUTION

This chapter describes the organization, time schedule and execution of the feasibility study. Information activities, public opinion and the public debate are discussed.

2.1 ORGANIZATION

After the decision was taken to allow a feasibility study to be conducted, an agreement and a programme for the feasibility study were drawn up /2-1/. The agreement between Storuman Municipality and SKB was signed on 28 September 1993. The agreement defines the responsibilities and the conditions for execution of the feasibility study. An addendum has since been made to this agreement clarifying the scope of the geoscientific investigations in the feasibility study (no drilling in rock). The feasibility study programme stipulates which subject areas are to be studied and how the work is to be organized. Figure 2-1 shows an organization chart with the subject areas included in the feasibility study.

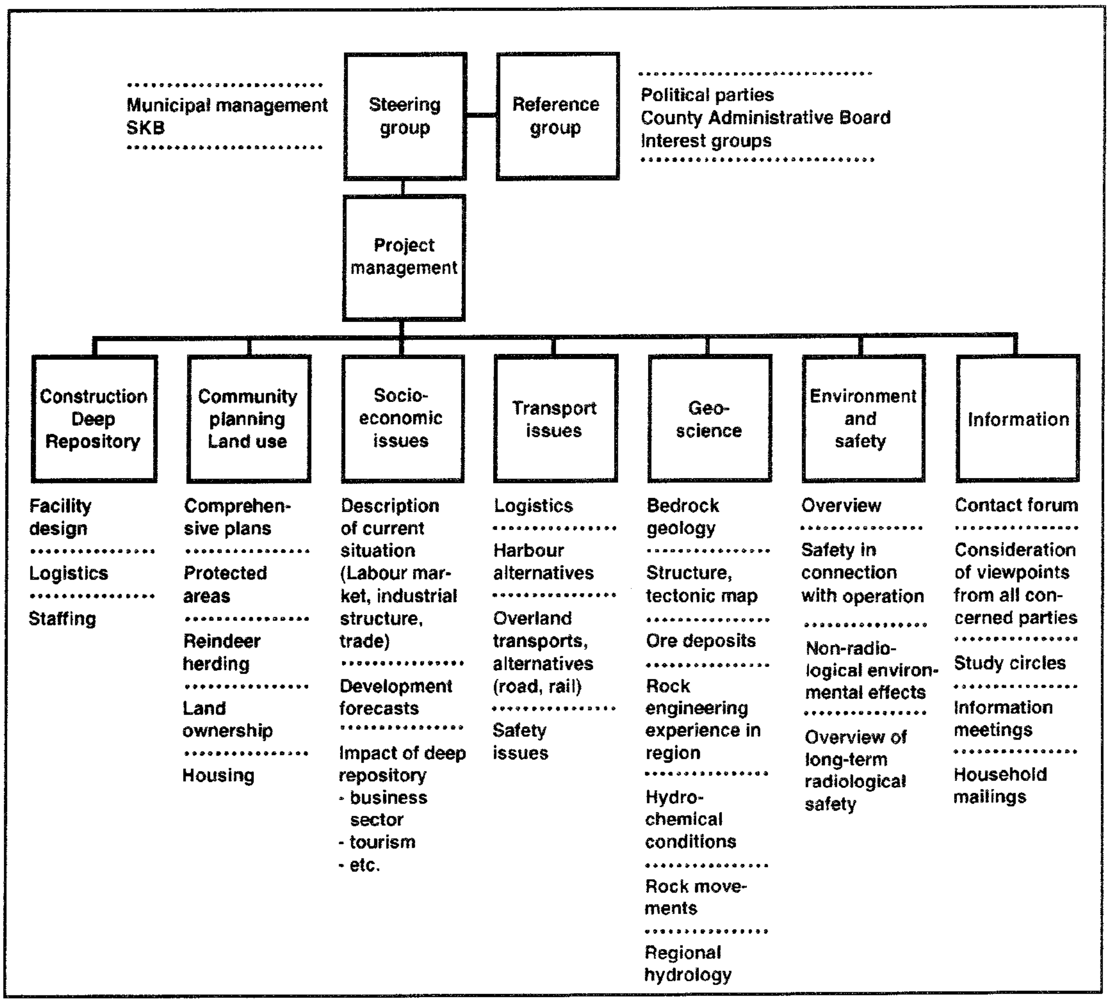


Figure 2-1. Organization chart listing the subject areas for study.

Responsibility for the study rests with SKB. The municipality has been given continuous information and insight through the project organization, enabling it to influence the work during the course of the project. The day-to-day work has been presided over by a project manager appointed by SKB. A municipal coordinator has been in charge of the municipality's activities in connection with the feasibility study. Principal investigators have been responsible for the subject areas shown in Figure 2-1. Experts from the geological survey, universities and consulting firms have been engaged to gather facts and conduct studies and analyses.

The project manager has reported to a steering group with two members from the municipality and two from SKB. The municipality have been assisted by a reference group consisting of 24 members appointed by political parties, the County Administrative Board, the Swedish Association of Local Authorities, local societies and other interested parties. The reference group has had the task of following the work and contributing opinions and ideas. Appendix 2 shows the composition of the reference group, and other persons who have taken an active part in the feasibility study.

2.2 TIME SCHEDULE

According to the agreement, a final report shall be submitted to the municipal council in Storuman by not later than June 1995. The time schedule for the framework programme that was drawn up in August 1993 /2-1/ was to complete all subject studies during the spring of 1994. A status report summarizing the results from all studies was published in June /2-2/. During the course of the work, the reference group pointed out the need to supplement the background material with additional studies or compilations. Such supplementary work has been done during the summer and autumn of 1994. The goal has been to present a final report around the start of 1995.

The time schedule is shown in Figure 2-2. It also shows that the municipality in its preparatory work plans to solicit viewpoints on the results of the feasibility study

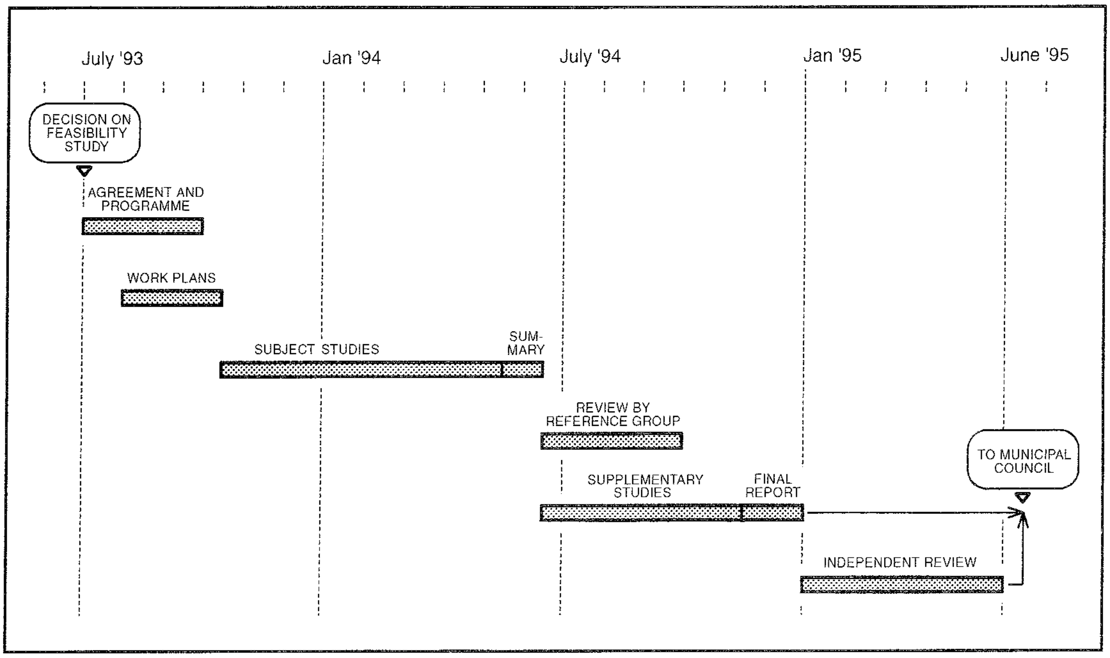


Figure 2-2. Overall time schedule for feasibility study.

during the spring of 1995 from bodies that have not participated in the feasibility study, before all material is submitted in June 1995 to the municipal council for further action.

2.3 EXECUTION

The work commenced with the drafting of work plans /2-3/ by the project manager and principal investigators, which was circulated for comment to the reference group and subsequently adopted by the steering group. Based on the work plans, experts and consultants were engaged within different fields to conduct various studies. The Department of Geography at Umeå University was contacted at an early stage to carry out and coordinate the socioeconomic studies. These studies were conducted according to a special programme /2-4/.

Several different consultancy firms and experts with long experience of studies in the interior of Västerbotten were engaged. The portion of the municipality within which the geoscientific surveys and the inventory of land-use plans were focused was delimited at an early stage /2-3/. (See Figure 5-1.) Land-use plans, environmental protection aspects and community planning questions were examined in close contact with the municipality and the county administrative board.

The spent nuclear fuel is being kept in the central interim storage facility for spent nuclear fuel, CLAB, north of Oskarshamn. The feasibility study's transport survey investigated possible transport modes and transport routes from CLAB to Storuman. Study trips were made to Skelleftehamn harbour, Umeå outer harbour/Holmsund and Hörnefors. Figure 2-3 shows the locations of these harbours in relation to Storuman Municipality and CLAB.

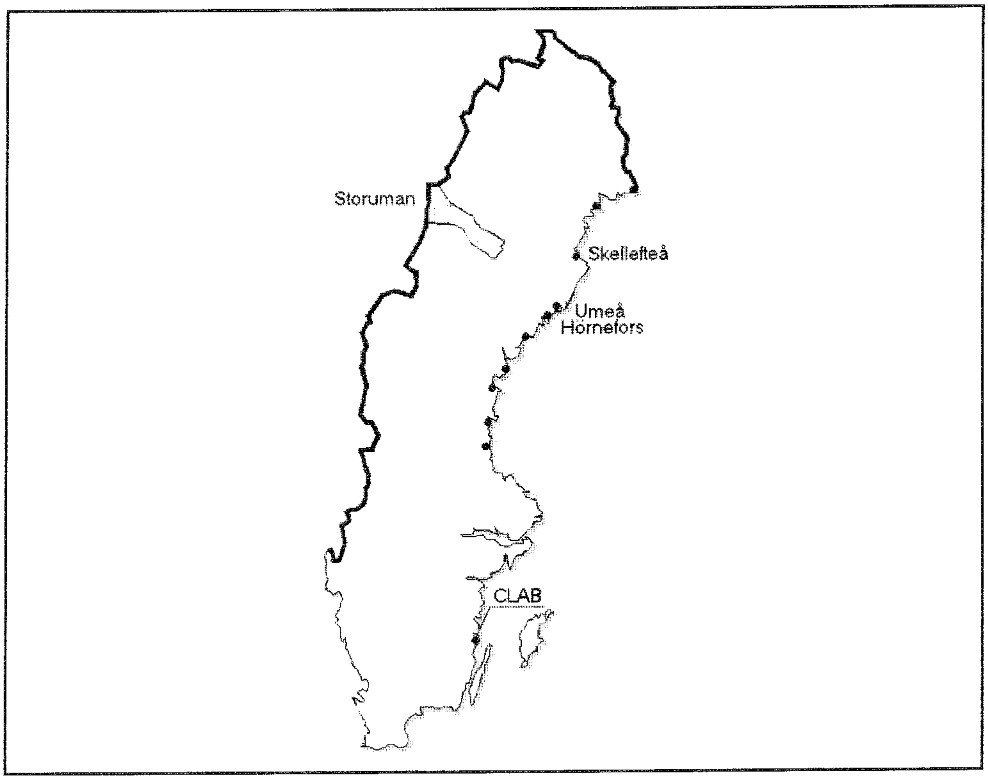


Figure 2-3. *Location of the Storuman municipality and studied local harbours. The spent nuclear fuel is temporarily stored in CLAB.*

The results of the various studies have been presented to the reference group and published as they have been completed. Altogether, around 30 documents and reports have been produced within the feasibility study. A list of published reports is provided in Appendix 3.

2.4 WORK OF STEERING GROUP AND REFERENCE GROUP

The steering group met approximately once a month. Ten meetings were held through November 1994. The reference group met seven times during the same period. On 25-26 January 1994, 22 members of the reference group made a study trip, visiting SFR at the Forsmark Nuclear Power Plant and CLAB and the Äspö HRL at the Simpevarp Nuclear Power Plant. In connection with the study trip, talks were held with the Swedish Nuclear Power Inspectorate, SKI, the National Radiation Protection Institute, SSI, and a representative of Östhammar Municipality (Forsmark).

Storuman Municipality has arranged four seminars for the reference group. In connection with the seminars, evening lectures with question-and-answer periods have been arranged for the public. The topics for the seminars and the evening lectures have been:

- Radiation and radiation protection (February 1994).
- Encapsulation and transportation (April 1994).
- Geoscientific premises (May 1994).
- Socioeconomic consequences (June 1994).

As a rule, the participants have been representatives of SKB, the municipality and representatives from universities, consulting firms and other experts who conducted the various studies. In some cases, representatives from SKI and SSI and other experts have also participated.

On 29-30 September, a geological excursion was made by the reference group to areas of interest for further studies. Interested members of the public and the media also participated in the excursion.

As previously mentioned, a status report was published in June 1994. The reference group, along with municipal officials, has submitted viewpoints on this report, which have led to some supplementary studies or adjustments and additions to the final report. A summary of the reference group's viewpoints on the status report, along with all minutes from the reference group's meetings through November 1994, are documented in a special report /2-5/, which also contains written questions from the group to SKB and SKB's replies. A summary of the reference group's viewpoints on the status report is provided in Appendix 4.

2.5 INFORMATION AND DEBATE

Ever since the question of a feasibility study arose, information activities have been intensive and the debate lively. SKB believes it is important and necessary to furnish information and hold a discussion of the planned studies at an early stage of the siting process.

SKB opened an information office in Storuman in the autumn of 1993. The office serves as a place of work for SKB's local representative and for persons who have worked with various studies in the feasibility study. Principal investigators have been stationed in Storuman every sixth week, according to a rolling duty schedule. There is an exhibit at the office which, besides describing the system for managing and disposing of Sweden's radioactive waste, also describes the progress of the feasibility study. Members of the general public, as well as groups from schools and associations, have visited the exhibit at the local office. Information material, including the minutes of the meetings of the steering group and the reference group, are available at the municipal office and SKB's site office.

Representatives from SKB have participated in school presentations and at meetings of various associations within the municipality and in neighbouring municipalities. Further, a number of newsletters describing the progress of the feasibility study have been distributed to all households within the municipality. Material for study circles entitled "Facts & Questions & Thoughts" has been produced during 1994, and the public has been invited to take part in the study circles. On three occasions, study trips to SKB's facilities in Forsmark and Oskarshamn have been arranged for the members of the reference group and municipal elected officials.

The debate has been intensive ever since the municipality contacted SKB to discuss a feasibility study. It has been reflected in the regional media and news articles as well as on the debate pages and in letters to the editor. The national media have also covered the issue. Altogether, there have been more than 1,000 items in the media on the subject during the period from January 1993 to November 1994.

An action group ("Action group against atomic garbage in Storuman") was formed in February 1993. The group started its activities by collecting signatures on a petition against a feasibility study. The action group has also been active by participating at meetings and issuing statements. A new petition was circulated for signatures in the spring of 1994 demanding that the feasibility study should be terminated.

Two other opinion groups have been formed. NAVET ("The business community's action group for lasting economic growth") and Veritas, which consists mostly of secondary-school students. Both of these groups are positive towards a feasibility study, without thereby committing themselves to the future disposal of nuclear waste in the municipality.

"Young and Proud", an association for young people, arranged, together with the municipality, a seminar for young people to which they invited groups for and against the feasibility study and representatives of Greenpeace, the municipality and SKB.

Several of the neighbouring municipalities and some municipalities along possible transportation routes have declared their opposition to a final repository in Storuman. Names have been collected on a petition opposing the shipments by an action group in Skellefteå.

Information meetings arranged by the municipality have been held on various occasions. Representatives of regulatory authorities have participated at some of these information meetings. In March 1994, a panel debate was arranged by Storuman Municipality and the action group. In addition to SKB, the panel included representatives of authorities, the ministry of the environment, Greenpeace, and critics associated with, among others, the Swedish Society for Nature Conservation. A panel debate on shipments was arranged in Skelleftehamn harbour by Skellefteå Municipality, also in March 1994. On March 17th, a one-hour TV debate was broadcast in Norrbotten and Västerbotten on nuclear waste management and the feasibility study in Storuman. Yet another regional debate programme was aired in October.

On 28 March 1994, the municipal council considered a motion to terminate the feasibility study. The motion was rejected with by a vote of 26 to 10, with 2 abstaining.

Municipal politicians and officials from other municipalities in the county have been given information on the work with the feasibility study on different occasions. A conference was held in August under the auspices of the Swedish Association of Local Authorities where the status report was presented.

A description of the information activities in which SKB has participated is given in Appendix 5.

3 SITING CRITERIA

3.1 GENERAL

There are certain fundamental requirements that must be met by a deep repository. Most importantly the long-term safety considerations must be addressed, and eventually the overall environmental consequences. These requirements are set forth in laws and regulations issued by the government authorities. The question of whether or not the requirements are met for a deep repository on a specific site will be determined by the authorities when they review the safety assessments and environmental impact assessments to be presented by SKB. Regardless of how the site has been selected, it is the results of such broad and detailed assessments of safety and environmental impact which will ultimately decide whether the deep repository may be built on the site in question.

A comprehensive assessment of long-term safety requires access to site-specific data on the bedrock conditions. Such data can only be obtained by means of extensive investigations on sites which must initially be selected on the basis of incomplete information. This distinguishes siting of underground facilities in general and a deep repository in particular from other industrial sitings (surface facilities) where knowledge of all important factors is relatively easily accessible. This in turn affects the strategy and organization of the siting work and judgement of the siting criteria.

The fundamental site requirements of a deep repository are described in RD&D-Programme 92 Supplement /3-1/. A summary of that account is provided here, with an emphasis on what is applicable in a feasibility study.

3.2 SITING FACTORS

The question of whether an area is suitable for siting of a deep repository is decided by the following main groups of siting factors /3-1/:

Safety	Siting factors of importance for the long-term safety of the deep repository.
Technology	Siting factors of importance for the construction, performance and safe operation of the deep repository and its transportation system.
Land and environment	Siting factors of importance for land use and general environmental impact.
Societal aspects	Siting factors connected to societal considerations and community impact.

Figure 3-1 shows how each main group contains a host of criteria and factors that determine the suitability of a site for a deep repository. Some of the factors are absolute criteria that must be met if a deep repository is to be built on a given site. Examples of such absolute criteria are that the groundwater shall be oxygen-free at repository depth, that mineral deposits (metals and industrial minerals) may not exist within the deep repository, and that the site may not be situated within a national park.

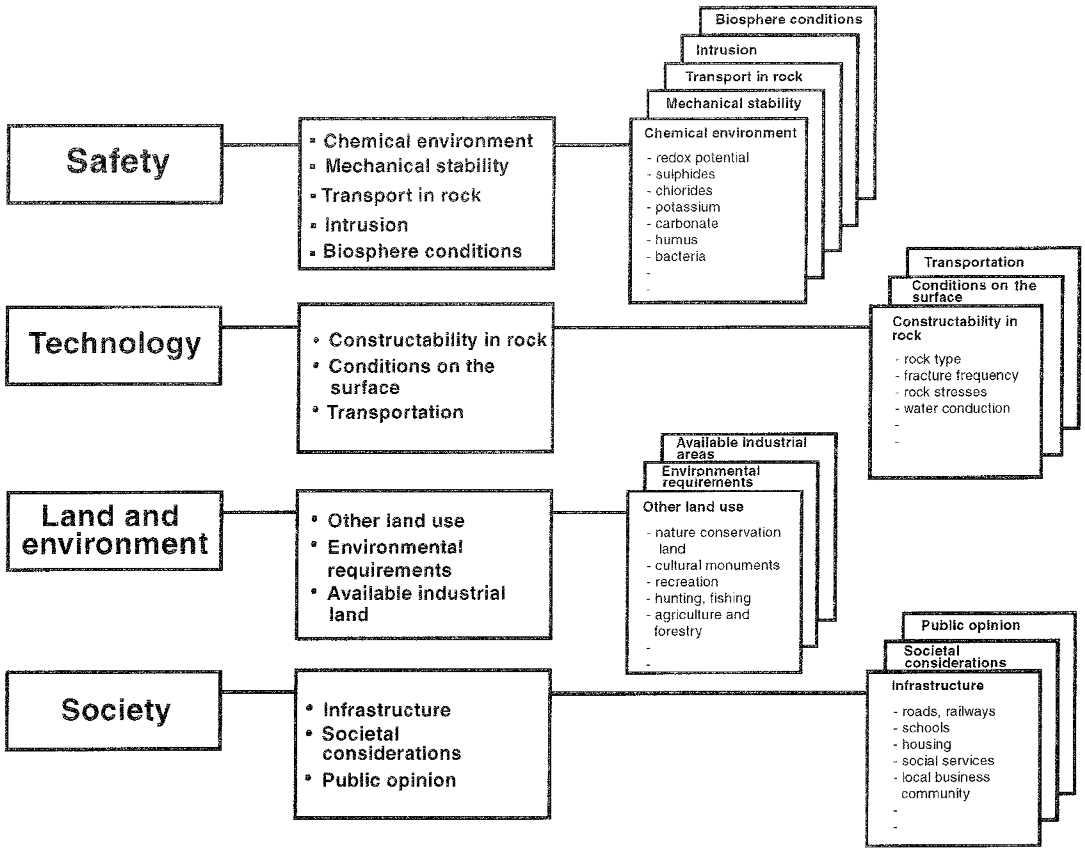


Figure 3-1. Structure for siting factors and criteria.

However, most factors fall along a scale of favourable – unfavourable, which means that they are important in an overall assessment of the suitability of the site, but are not by themselves crucial in deciding whether a site is suitable. Examples of unfavourable conditions are heterogeneous bedrock, long distance to an existing road/railway and competing land-use interests.

The requirements within each of the four main groups can be formulated as follows:

Safety

The fundamental safety principle for the deep disposal system planned by SKB is to completely contain and isolate the spent nuclear fuel in tightly sealed canisters deposited at a depth of about 500 metres at the selected repository site. This isolation shall be achieved and preserved over very long periods of time so that the radioactive materials decay inside the canister and cannot be released. This means that an important safety-related function of the rock is to guarantee stable chemical and mechanical conditions for the engineered barriers over a long period of time.

The safety strategy for a deep repository is based on the multiple-barrier principle. This means that safety must not be solely dependent on the engineered barriers' functioning as planned. Another important safety-related function of the bedrock at a deep repository site is to retain the radionuclides or retard their transport if the engineered barriers should be damaged.

For the sake of long-term safety, the following factors must be taken into consideration when selecting a site:

- chemical environment in the rock for canister, bentonite and fuel;
- mechanical stability of the rock;
- conditions for transport of corrodants and radionuclides in the rock;
- risk of future intrusion, i.e. mainly conceivable utilization of natural resources in the bedrock.

For a more complete treatment, see /3-1/.

Technology

Transportation and ground conditions

The requirements that transportation shall be safe can as a rule always be met by the use of appropriate technology and the necessary investments. It is advantageous if an existing infrastructure for sea and land transport can be utilized. It is a disadvantage if extensive new investments are required and if new harbours, roads or railways conflict with other important land-use interests.

The surface facilities at the repository are responsible for reception of all goods plus buffer storage and transloading before the materials are taken underground. They shall be designed and equipped so that the requirements on public safety, occupational safety, radiation protection and environmental protection are met. It is an advantage if the facilities are located not too far from existing infrastructure such as public transport, railway, social services, etc. The ground conditions at the site of the surface facilities must be sufficiently competent to bear the load of surface buildings.

Constructability in rock

The parts of the bedrock where shafts, access tunnels, transport tunnels, deposition tunnels etc. are planned shall possess such properties that the work can be carried out in a safe manner using known technology.

By international comparison, Sweden exhibits good geological conditions for rock construction. Long and extensive experience exists from siting and construction of different types of underground rock facilities. Experience has revealed nothing to indicate that a particular area on a regional scale is particularly unsuitable. Suitability is more tied to local conditions.

When data from repository depth have been reported, the suitability of an area for construction purposes can be determined based on factors such as rock type, fracture frequency, location and character of fracture zones, hydraulic conductivity, size and orientation of rock stress and mechanical properties of the bedrock.

Land and environment

Site selection and design of the facilities shall be done so that conflicts with competing interests are minimized. Consideration shall thereby be given to the natural, environment, cultural monuments, recreation, hunting, fishing, other outdoor activities, important natural resources, agriculture and forestry, current and planned land use. Facilities and transport routes shall blend in smoothly with the terrain.

To comply with the requirements in the environmental legislation, the facility's environmental impact must be weighed against the specific environmental conditions in the area early in the siting process.

The site for the deep repository shall have:

- few competing interests for land use;
- good prospects for being able to build and operate the facilities in compliance with all environmental protection requirements.

Societal aspects

Socioeconomic considerations are important for both site selection and design of the facilities on the selected site. The establishment and operation of a deep repository will have different impacts on the locality and the region. These include e.g. impact on employment, the local business community and local services. Politically and in terms of public opinion, siting is a sensitive issue. Experience in both Sweden and other countries shows that strong feelings and opinions can be aroused. Opposition to industrial sitings in general are not unusual in modern society. Siting of a deep repository shall be carried out so that:

- the siting process are carried out in stages involving a democratic decision-making process;
- social and socioeconomic consequences are taken into account.

3.3 APPLICATION OF CRITERIA IN A FEASIBILITY STUDY

The factors and criteria that are discussed in preceding sections must be taken into account in an overall assessment of a chosen site. However, many factors that are important for the long-term safety and construction-related aspects can only be clarified after comprehensive investigations on the site. Until then it is necessary to rely in large measure on general knowledge in the selection of study areas.

In a feasibility study, when knowledge of the properties of the bedrock at repository depths are incompletely known, the work must primarily be focused with identifying and analyzing geoscientific conditions that may be unsuitable or unfavourable on the basis of generally available information. Conditions that should be avoided are, first and foremost:

- highly heterogeneous and difficult-to-interpret bedrock conditions;
- rock types of interest for mineral extraction or other exploitation;
- known deformation zones and neotectonic faults;
- pronounced discharge areas for groundwater;
- abnormal (for Swedish bedrock) groundwater chemistry.

Key questions for the remaining aspects are:

- which areas have particularly good chances of meeting the requirements with regard to safety, technology, land and environment, and societal aspects?
- which of these areas offer good opportunities for later carrying out a reliable characterization of, above all, the important environmental and safety factors?

The following conditions are thereby primarily favourable (give a "good prognosis"):

- a common rock type unsuitable for other utilization of natural resources. This reduces the risk that the area will be of interest for other use in the future;
- a large area with few major fracture zones. This provides extra flexibility in connection with coming investigations and improves the prospects of being able to construct a repository with room for the necessary number of canister positions in suitable rock with a high level of safety;
- a high degree of exposure, simple and homogeneous bedrock conditions and a regular system of fractures and fracture zones ensure good prospects for obtaining a sound understanding of bedrock conditions with a bearing on safety and constructability.

The following conditions are also favourable:

- local positive interest;
- access to the necessary infrastructure and good transport options via existing harbours, railways or roads. Limited need for new investments in road or rail;
- few competing land-use and environmental interests means good opportunities for adapting the facilities so that the environmental requirements are met in a satisfactory fashion.

Based on these criteria, the second stage of the feasibility study goes on to identify those areas deemed to be of primary interest for possible further investigations and make a rough evaluation of these areas. The results of the feasibility study in this respect will then be one or more prioritized areas for possible continued siting studies (site investigation). These areas will later be evaluated against equivalent areas from other feasibility studies, whereby a selection will be made of those areas (and thereby municipalities) which, according to SKB, should be the object of site investigations. Prioritization does not mean that all other areas are unsuitable, but merely that the prioritized areas are of the greatest interest, judging by available data. (More comprehensive studies might lead to a different prioritization.)

Figure 3-2 shows in schematic form the different steps in the process of selection of areas that has been carried out in the feasibility study.

Coming chapters present the analysed material that has been gathered in the course of the feasibility study and that has been used in the selection of areas of interest for further studies. An evaluation based on the aforementioned criteria is made at the end of each chapter. A summary assessment is made in Chapter 11.

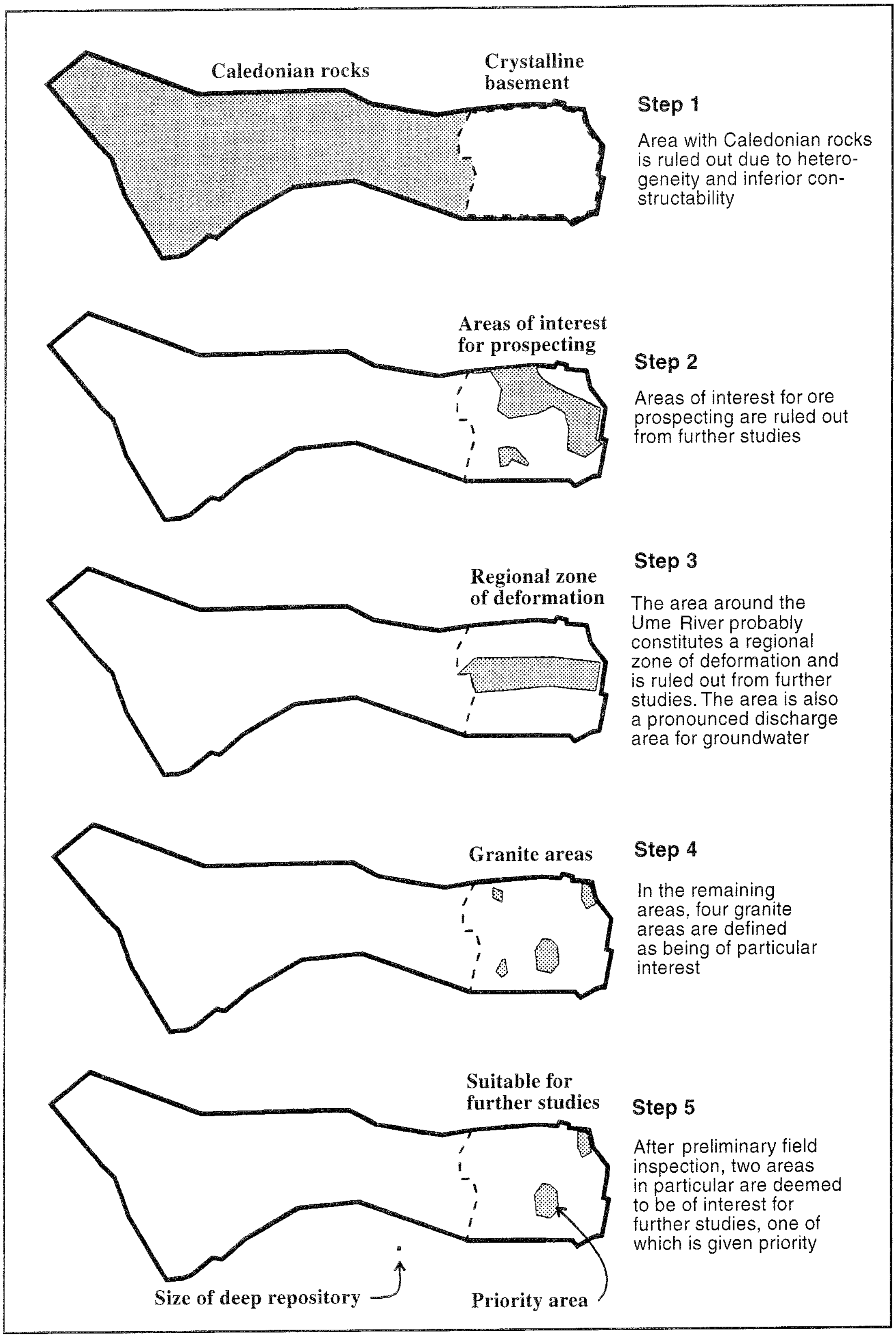


Figure 3-2. Schematic illustration of the step-by-step process of identifying areas that can be of interest for further studies. In the first three steps, those parts of Storuman Municipality deemed to have unsuitable or less suitable properties were ruled out from further studies. Subsequently the studies were focused on identifying which of the remaining areas might be of interest for further investigations. For information on scale and other geographic conditions, see Figure 4-1.

4 STORUMAN MUNICIPALITY – BRIEF INTRODUCTION

This chapter provides an introduction to Storuman Municipality. Orientation maps are presented showing the locations of towns and areas mentioned in the report.

4.1 THE MUNICIPALITY AND ITS HISTORY

The municipality of Storuman, which was created in 1971 by the amalgamation of the municipalities of Stensele and Tärna in Västerbotten County, is in many ways a typical rural inland Norrlandian ("Norrland" is the northern, sparsely populated part of Sweden) municipality. It covers an area of 7500 square kilometres with both mountainous and forested parts. The population density is low (about 1 inhabitant per km^2). Maps of the municipality are presented in Figures 4-1 and 4-2.

Most of the municipality's population lives along the Ume River and the lakes through which it flows. Otherwise human settlements are few and far between. Approximately 3,500 of the municipality's roughly 7,600 inhabitants live today in the centre of the municipality in the twin communities of Storuman and Stensele. Just under 2,000 people live in the Tärnaby/Hemavan area.

Storuman is a crossroads with relatively good opportunities for different types of transport and travel. Here the Blue Road (E12 between Umeå and Mo in Rana) crosses the north-south inland route (national highway 45). The two rail lines known as *inlandsbanan* (the inland railway, running north-south) and *tvärbanan* (the cross railway, running northwest – south east) meet in Storuman.

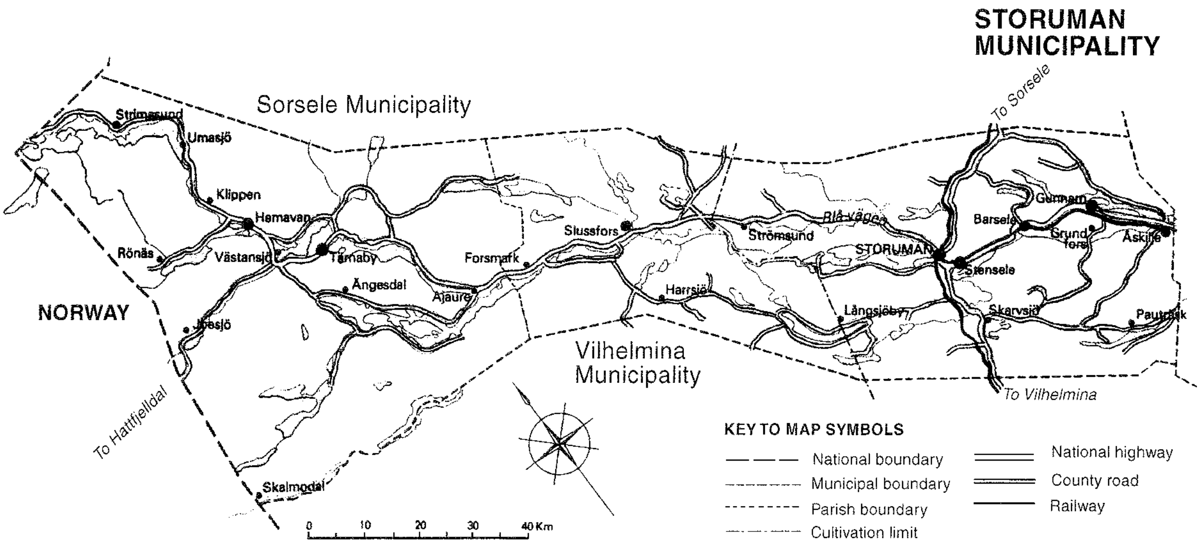


Figure 4-1. *General map of Storuman Municipality.*
(Source: Address map of Storuman-Stensele, Storuman Municipality / Liber maps).

Some of the places in the municipality of Storuman that are mentioned in this report but are not shown on other maps are marked with numbers on the general map on the opposite page.

They are, in alphabetical order:

1. Buberget
2. Granbergstjärn
3. Gunnarbäcken
4. Joran
5. Juktan tunnel and Juktan hydropower station
6. Juktå colony
7. Kyrkberget
8. Luspberget
9. Lycksamyran
10. Namonsbäcken
11. Olbon
12. Sabotsliden
13. Skirträsket
14. Storbäcken
15. Verkanliden

Figure 4-2. *General map of eastern part of Storuman Municipality with environs, scale 1:500,000. (1 cm on the map corresponds to 5 km in reality).*

Source: The "red map" of Västerbotten. Published with the consent (dnr 420-242-82) of the National Land Survey.

Two distinct periods during the 20th century with relatively large infrastructure building projects, railways and hydropower plants, have contributed to the modern development of the central localities of Storuman and Stensele. With the coming of the inland railway and the cross railway during the 1920s and '30s, Storuman became the main station between Östersund and Gällivare. This shifted weight from the former central locality of Stensele to the present-day one, Storuman. Today Storuman and Stensele are almost interwoven twin communities.

The hydropower epoch, when Vattenfall harnessed the Ume River with hydroelectric plants (at Grundfors, Stensele and Umluspen) reached its apex during the 1950s, but continued virtually without interruption up until 1978. In 1990 work began on the power plant in Klippen in the upper reaches of the river. With the commissioning of this power plant in the autumn of 1994, virtually all hydropower within the municipality has now been harnessed.

Reindeer herding in the municipality is centred around two Sami villages, Vapsten south of the Ume River and Umbyn north of it. Nowadays the reindeer herders employ modern methods and equipment.

Nature is regarded as a great asset in Storuman Municipality with its rich opportunities for outdoor activities, recreation, hunting, fishing and tourism in various forms.

Agriculture and forestry used to dominate the economy, with reindeer herding as an important alternative, but today the picture is more varied. The role of agriculture and forestry as economic sectors has steadily declined in the municipality during the past few decades. Several other basic enterprises such as electric power production, transportation, construction and an expanding tourist industry (especially in the Tärnafjällen district) have instead increased in importance. Loss of jobs and population has, however, been considerable for several decades, and many enterprises are wrestling with problems today. The socioeconomic conditions in the municipality are described in Chapter 10, which also presents forecasts regarding future development with and without a deep repository.

5 GEOSCIENTIFIC PREMISES

This chapter summarizes what is known about the geoscientific conditions in Storuman Municipality. Based on these conditions, a preliminary assessment is made of the geological prospects for siting a deep repository in the municipality.

5.1 INTRODUCTION

In order for a site to be considered suitable for a deep repository from a geoscientific point of view, the bedrock must fulfil certain criteria. Even though general geological data and experience can provide a good picture of the prospects, the suitability of the site must be studied more thoroughly with the aid of safety assessments. Such assessments require site-specific data from boreholes. Data from tunnels and shafts are required for the final geometric design of the repository and the final safety analysis. It is therefore not until detailed characterization has been carried out, i.e. when the results of investigations in tunnels at repository depth have been presented, that a basis exists for such a thorough assessment of the suitability of the bedrock that a final decision can be made as to whether the repository is to be built on the site.

The geoscientific part of the feasibility study has mainly been focused on investigating whether geological conditions exist that make the municipality unsuitable for a deep repository from a general point of view. Subsequently the studies were focused on identifying areas of interest for further studies.

Field reconnaissance studies have been conducted within four geologically interesting areas. These studies, like the other geoscientific surveys in the feasibility study, are of a general nature, and all judgements must therefore be regarded as preliminary.

5.2 SCOPE

Good general knowledge exists regarding the geological conditions in Storuman Municipality as a result of the ore prospecting activities and the extensive civil engineering projects that have been undertaken there. The state of geoscientific knowledge has been described in the following reports (in Swedish only):

- Storuman Municipality in a regional geological context.
- Description accompanying geological map of the crystalline basement in Storuman Municipality.
- Ores and minerals within Storuman Municipality.
- Description accompanying soil map of the Storuman area.
- Geophysical documentation and interpretation.
- Hydrochemical conditions.
- Storuman Municipality, geohydrological description.
- Geological field reconnaissance studies and geophysical interpretation of areas of interest.

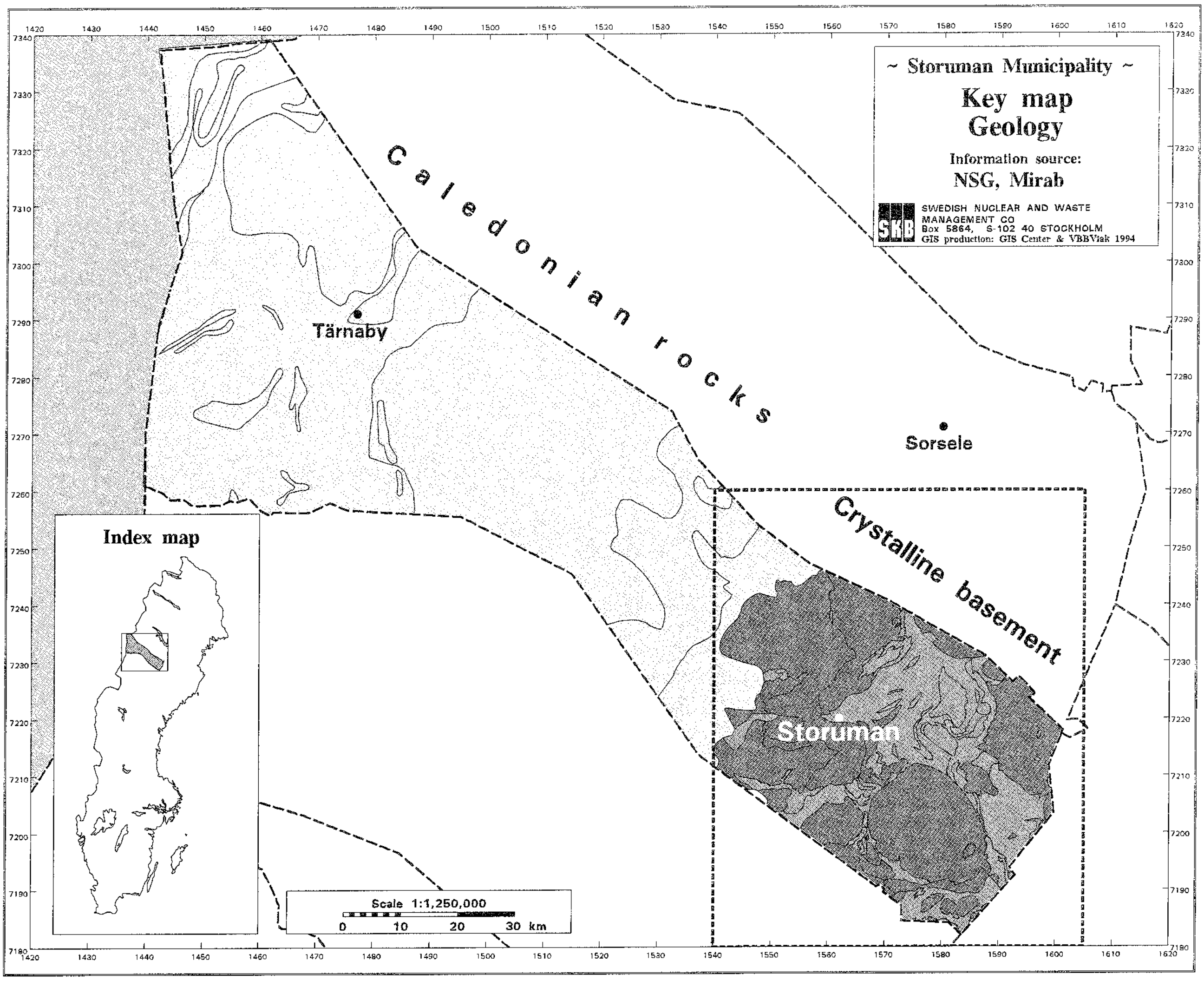


Figure 5-1. Boundary between crystalline basement and Caledonian rocks in Storuman Municipality. The rectangular area is the feasibility study's geoscientific study area /5-1/.

- Rock construction experience in a regional and local perspective.
- Juktan pumped storage hydropower station – summary of geological and hydrogeological information.

The results of the two last-named rock engineering surveys are mainly discussed in section 6.7. Furthermore, an assessment of the prospects for siting a deep repository in areas of geological interest, viewed from societal and environmental viewpoints, is presented in Chapter 8.

The central and western portions of the municipality /5-1/ were judged already in an initial phase as being of no interest, since they consist of Caledonian rocks, which are generally speaking less suitable for a deep repository. The geological studies have therefore principally concerned the crystalline basement rock in the eastern part of the municipality. Figure 5-1 shows where Caledonian rocks and crystalline basement rock are found within the municipality and the feasibility study's geoscientific study area.

5.3 BEDROCK

The bedrock in approximately 70% of Storuman Municipality consists of Caledonian rock types that were formed 520-400 million years ago /5-2/. They are often heavily deformed and heterogeneous due to their having been thrust over the underlying crystalline basement. The heterogeneity of the Caledonian bedrock, in combination with a severe topography, makes it unsuitable for a final repository. It is possible to locate a deep repository in the crystalline rock underneath the Caledonian bedrock, but such a siting would require the development of a different investigation methodology than the one heretofore employed in the Swedish nuclear waste programme.

In the eastern part of the municipality, the crystalline basement is exposed. Most rock types here are older than 1,750 million years /5-3/. The crystalline basement is dominated by large granite bodies and supracrustal rocks. The latter were originally deposited on the seabed or on land and have since been relocated down into the bedrock by means of various geological processes, where they have been converted to black shales, greywackes, gneisses, etc. Figure 5-2 shows a geological map of the feasibility study area.

There are several generations of granites; the oldest are often foliated and are relatively limited in extent. In contrast, the ones that dominate the crystalline basement are more or less massive and belong to the Revsund granite series. These granites have pushed up like "mushrooms" and form characteristic round or oval bodies called granite domes. These domes occupy a total area of 60% of the municipality's crystalline basement. The Joran dome is the largest granite dome and stands out distinctly on the geological map in Figure 5-2 between Grundfors and Pauträsk. It has an area of more than 300 km^2; geophysical calculations of its depth vary between 0.5 and 3 km /5-5/.

Several granites in Storuman exhibit considerably higher uranium and thorium concentrations that is normal for granites in Sweden. Normally for Sweden the uranium concentration lies around 2-10 grams/tonne, while certain granites northwest of the community of Storuman can have uranium concentrations of 10-50 grams/tonne /5-3/. Granites with high uranium concentrations also occur at other places in the municipality. Figure 5-3 shows uranium concentrations at the ground surface calculated from aeroradiometric measurements. Each point represents an average value over an area of 200 x 200 m. The radiation comes from the uppermost part of the soil/bedrock, so caution must be observed when translating these measurements to the concentration of uranium or thorium in the underlying bedrock.

The high uranium concentrations have given rise to radon problems in certain residential areas /5-6/ and underground facilities /5-4/. How radon can affect the design of a deep repository is described in section 9.3.

5.4 FRACTURE ZONES

Lineament interpretations are often used to estimate the frequency of fracture zones. Lineaments in the landscape – such as valleys, strings of mires, terrain benches and straight lake contours – usually correspond to steep fracture lines (faults and fracture zones) in the underlying bedrock. Experience from underground constructions largely supports these assumptions. Figure 5-4 shows a map of fracture zones interpreted from lineament maps /5-5/, which are in turn based on topographical features and from aerial magnetic and electrical maps.

Legend to map symbols

~ Bedrock geology ~

- Caledonian bedrock
- Diabases

Postorogenic – Serorogenic Intrusive rocks

- Grey to reddish-grey coarse-grained to coarse-porphyritic granite
- Grey medium-grained granite
- Fine medium-grained granite (grey-red)
- Grey fine to medium-grained two-mica granite
- Quartz monzonite and monzonite

Early orogenic intrusive rocks

- Granodiorite, diorite and tonalite
- Gabbro and ultrabasite

Supracrustal rocks

- Basic intermediate vulcanites (Greenstones)
- Greywackes, shales, sandstones, conglomerates
- Graphite- and silicon-bearing shales (Black shale)

- Gp Granite porphyry dykes
- Q Pegmatite and aplite dykes
- Xenoliths of sediment or vulcanite in granitoids
- Migmatization
- Major faults and zones of weakness

- Municipal boundary
- Public road
- Railway
- Urban area
- Terrain shading

kommun = Municipality

Figure 5-2. Geological map of the municipality's crystalline basement /5-3/.

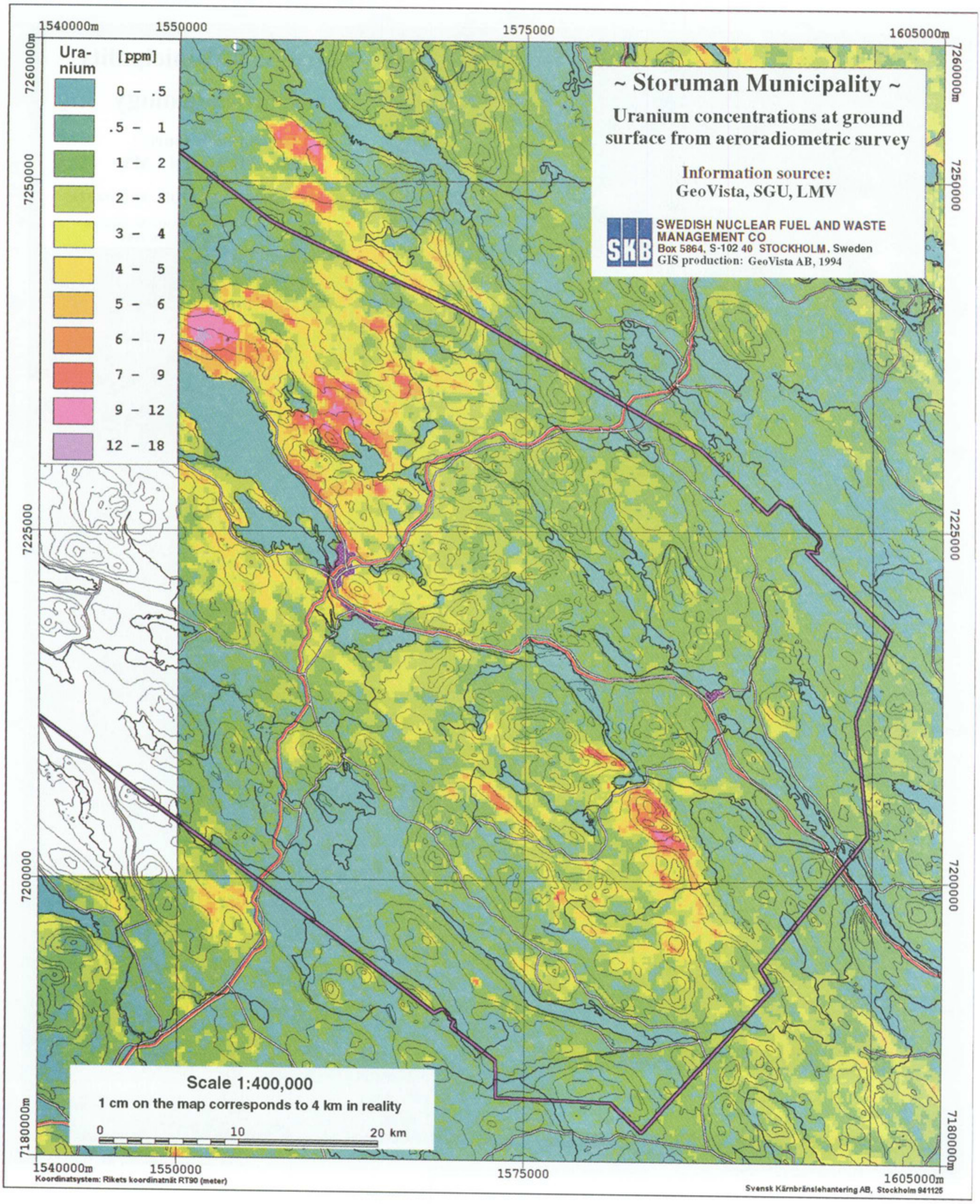


Figure 5-3. Uranium concentrations at the ground surface in the eastern part of Storuman Municipality calculated from radiation measurements from aeroradiometric survey /5-4/.

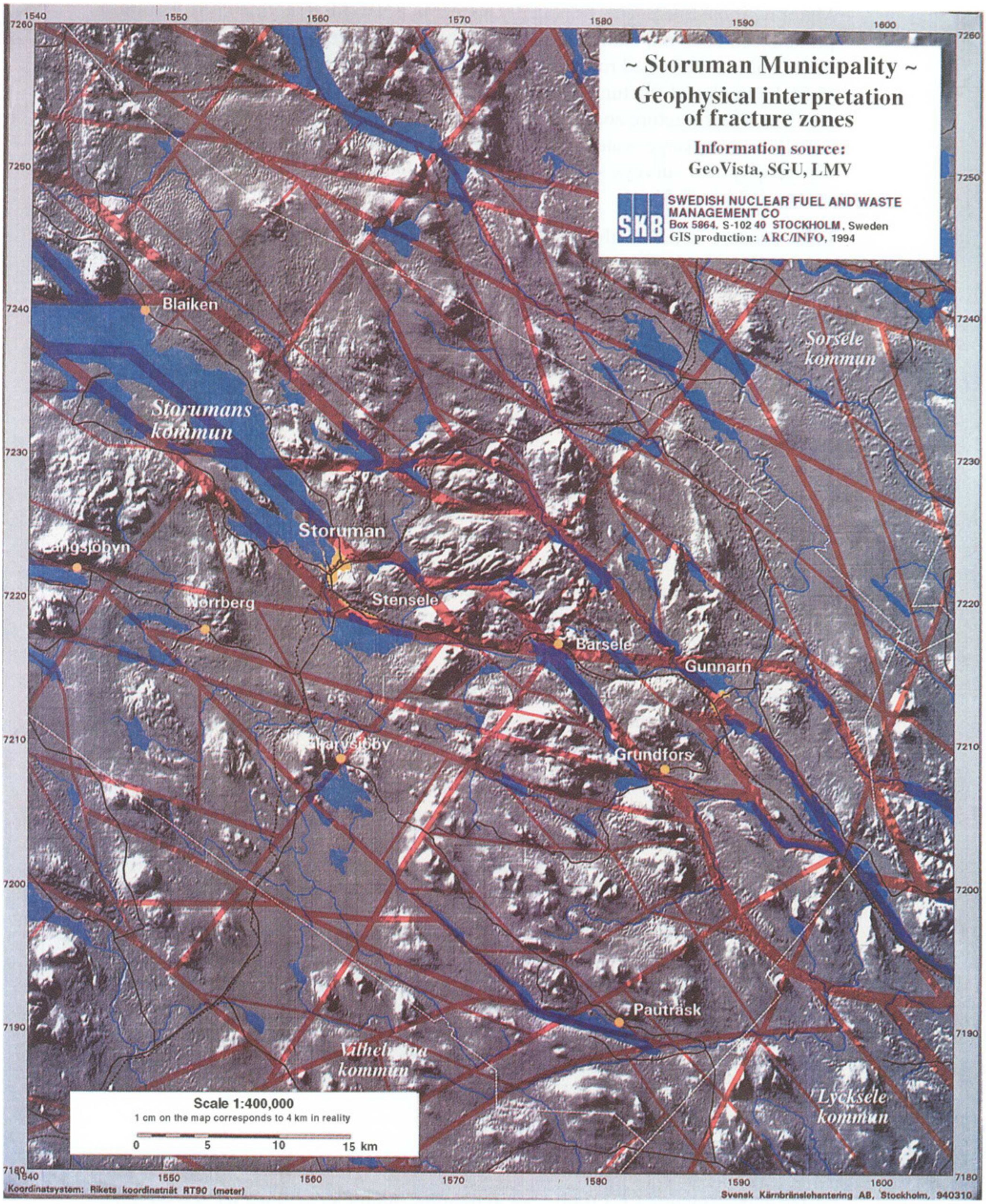


Figure 5-4. *Interpreted fracture zones (lineaments) based on topographical fractures (digital elevation data) and on magnetic and electrical measurements from aerogeophysical surveys /5-5/.*

Major regional lineaments principally appear in a NW-SE direction /5-5/. The most pronounced ones run along the valley of the Ume River, which is interpreted as a major zone of deformed rock stretching from the mountain range down to the coast /5-5/. Examples of fracture zones in this direction, which can possibly be linked to the Ume River fracture zone, are those that appeared in the lower part of the Juktan tunnel, causing large water inflows. Within the major granite areas in Storuman, aerogeophysical surveys suggest that smaller, local fracture zones occur at intervals of 1-2 km /5-5/.

Most fracture zones in the Swedish crystalline basement are very old and were originally formed more than a billion years ago. These zones constitute planes of weakness in the rock along which rock movements can occur if the bedrock is subjected to large stresses. The most recent large stress resulted from the continental ice sheet, which was about 3 km thick at its peak. It has been found that large rock movements occurred in certain fracture zones in northern Scandinavia in conjunction with the retreat of the ice sheet some 9,000 years ago. These rock movements were accompanied by major earthquakes /5-2/.

A report describing the soils in the municipality /5-7/ mentions the fact that aerial photographs taken over the area north of Gunnarn showed "topographical benches" in the moraine terrain with a throw of about 10-15 m and several km in length. The report says that these benches may indicate that fault movements have taken place in the bedrock in conjunction with the retreat of the ice sheet. The short length of these structures, among other things, is contrary to this hypothesis. (According to rock-mechanics theory and observations from known faults, a fault displacement of 10 m between two rock blocks should correspond to a fault length of several tens to hundreds of kilometres, which is the case, for example, with the aforementioned faults in northern Scandinavia.) A field inspection /5-11/ of Storuman's neotectonic indications showed that more investigations (particularly trench excavations) are needed to determine their origin.

Rock movements are an example of events that can damage a repository if the actual fault movement directly transects a canister and if the movement is sufficiently large. Studies of e.g. the Lansjärv neotectonic Fault in Norrbotten /5-2/ show that rock movements tend to occur along pre-existing very old and relatively easy-to-interpret fracture zones, which can be avoided in a deep repository.

Storuman is situated in a part of Sweden which is presently seismically stable /5-2/. The few earthquakes that have been registered in modern time usually derive from small rock movements at great depths – much deeper than a deep repository, and involving smaller fault displacements than are required to damage a waste canister. Major earthquakes might possibly be expected at the end of the next ice age.

5.5 ORE POTENTIAL

Areas with a potential for future ore extraction should be avoided when searching for a site for a deep repository. An important task for the feasibility study has been to describe and evaluate the known mineral deposits in the municipality and to judge the extent of areas where mineral extraction might be considered in the future /5-8/, /5-2/.

Extensive prospecting activities during the past few decades have contributed to a relatively broad body of geological data from crystalline rock areas in Storuman. Many areas with mainly supracrustal rocks have been investigated with modern prospecting methods for base metals and gold. The possibilities of finding gold deposits have also been studied in recent years in connection with shear zones and small granite intrusions. An inventory has been made of the entire municipality's crystalline basement area as regards tungsten, tin, molybdenum and uranium /5-8/. The Caledonian front has been explored for deposits of lead, fluorite, baryte and uranium. Prospecting for industrial minerals and ornamental stone has, by contrast, heretofore been sporadic.

Figure 5-5 shows the currently active claims and mineral concessions. The figure also shows older, inactive mineral concessions where prospecting has not led to positive findings. Certain claims have been staked based on geochemical indications and are much larger in area than the actual target area. Such claims, popularly known as protective claims, give a somewhat skewed picture of how prospecting activities have actually been conducted. In general, it can be said that a large claim seldom reflects a large mineral find. As an example it can be mentioned that an application was submitted in the autumn of 1994 for a claim to all of northern Sweden down to Dalarna for diamonds.

Areas with ore potential cover approximately one-third of the crystalline basement. In the main, these areas are located where supracrustal rocks dominate. Two parts of the municipality are judged to have a greater ore potential than others, namely a belt from Storuman in the south via Gunnarbäcken towards Storjuktan in the north, and an area within the triangle Barsele-Gunnarn-Orrträsket in the southern part of the municipality /5-8/. These areas contain a number of mineral deposits and can be designated as ore provinces. These areas contain several mineral deposits that are almost economically workable.

Mineralizations in granites, mainly tungsten and tin, have been studied in greater detail in the feasibility study, since granites can generally be considered to be suitable for a deep repository. In general it can be observed that these mineralizations are clearly indicated by geochemical prospecting (chemical analysis of soil samples). Such prospecting has been conducted all over the municipality's crystalline basement section. All major and superficial mineralizations of this type can thereby be considered to have been found /5-8/.

There is no potential for mining of industrial minerals in the four granite areas of geological interest /5-11/. The potential is also low for extraction of commercial stone in the form of crushed fill or ornamental stone.

5.6 HYDROCHEMICAL AND GEOHYDROLOGICAL CONDITIONS

Studies have also been conducted of what is known regarding the chemical composition of the groundwater /5-6/, precipitation, runoff and groundwater flow /5-10/ as well as evaluation of water capacities in rock bored wells (appendix to /5-9/).

The chemical composition of the groundwater has been evaluated from existing analyses of water from 39 bored wells and 67 dug wells in the eastern portion of the municipality. The sampling points have a relatively good geographical spread, but are few in relation to the size of the area.

The groundwater, especially in the rock bored wells, is characterized by soft to very soft water with low chloride and sulphate contents. A trend towards increased content of solutes and increasing alkalinity, total hardness, chloride content, sulphate content and content of anions and cations with increasing borehole depth has been demonstrated. Increasing concentrations of iron and manganese with depth indicate a transition to reducing (oxygen-free) conditions. The available data do

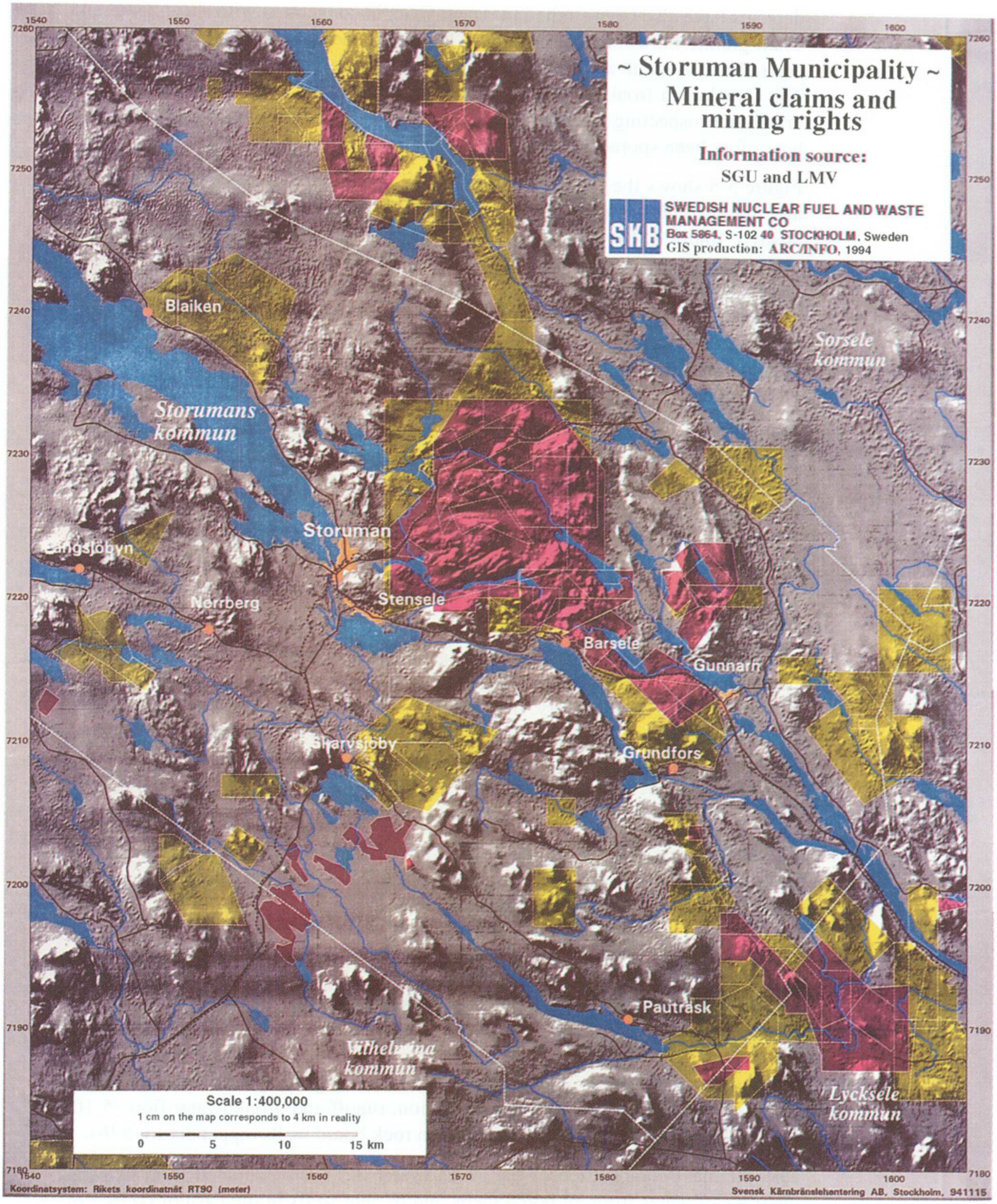


Figure 5-5. Claim situation (October 1994). Red indicates active claims and mining concessions, yellow indicates inactive claims /5-8/.

not permit any far-reaching conclusions to be drawn on chemical conditions at repository depth. However, the data do indicate that favourable conditions presumably prevail at this depth and that no directly unsuitable factors are expected, such as high sulphide concentrations or oxidizing conditions.

The geohydrological survey shows that virtually all of Storuman Municipality lies within the drainage basin of the Ume River. Hydrometeorologically, the municipality is characterized by a heavy increase in precipitation towards the mountain district in the west. An evaluation of water capacities from 3,500 wells in Västerbotten County shows that of the rock types that occur in Storuman Municipality, diabase (dolerite), and to some extent gabbro and diorite, is less water-bearing than others. The differences in mean values between the rock types are small, however, and lower than differences in water capacities within each rock type.

Taken together, the hydrochemical and geohydrological studies have not yielded any surprises and conditions can be regarded as normal for Swedish crystalline basement. However, it must be remembered that these surveys are based on superficial data, down to a depth of about 100 m. These data can be used, as here, for rough assessments, but borehole measurements are required to determine the actual conditions at repository depth.

5.7 STUDIED AREAS

Several studies /5-3/, /5-5/, /5-9/ conclude that favourable conditions might exist in the large granite domes. Geological and geophysical data suggest that within these domes large volumes of homogeneous granite can be expected with relatively few fracture zones and without ore- and mineral-bearing structures. Experience from existing underground facilities in Storuman also suggests that good construction-related conditions can be expected, even though uncertainties exist concerning the presence of high rock stresses (see section 6.7). The supracrustal rocks, on the other hand, generally seem to be less promising due to the fact that they are heterogeneous, contain areas of mineralization and in many cases have proved to give rise to rock engineering problems in underground facilities /5-4/. At the same time it should be mentioned that there are also examples of rock facilities that have been satisfactorily constructed in these rock types.

The status report /5-12/ presented four granite areas as being of interest for further studies, and the locations of these areas are shown in Figure 5-6. Reconnaissance field studies were made in these areas during the summer of 1994. Furthermore, a geophysical evaluation of existing data with supplementary field studies has been carried out. The results of both these studies are reported in /5-11/, along with an assessment outlining the potential of the areas for mining of industrial minerals and quarrying. A summary of these studies is presented below.

The northern area, **Olbon** on the southwest slope of Storblaiken, consists mainly of a two-mica granite. Diabase (dolerite) and lamprophyre dykes occur adjacent to the area. The bedrock is well-exposed.

Data occurring from the Juktan tunnel indicates a bedrock with small water inflows between the power station area and Mellansänket, i.e. in the area where the two-mica granite appears. Below Mellansänket, towards Storuman, the rock conditions deteriorate considerably /5-9/. (See Chapter 6.)

The reconnaissance field studies show that the two-mica granite is texturally heterogeneous comprising varying grain sizes and the occurrence of occasional apalite dykes. There may possibly be an approximately 10 km^2 area in the central

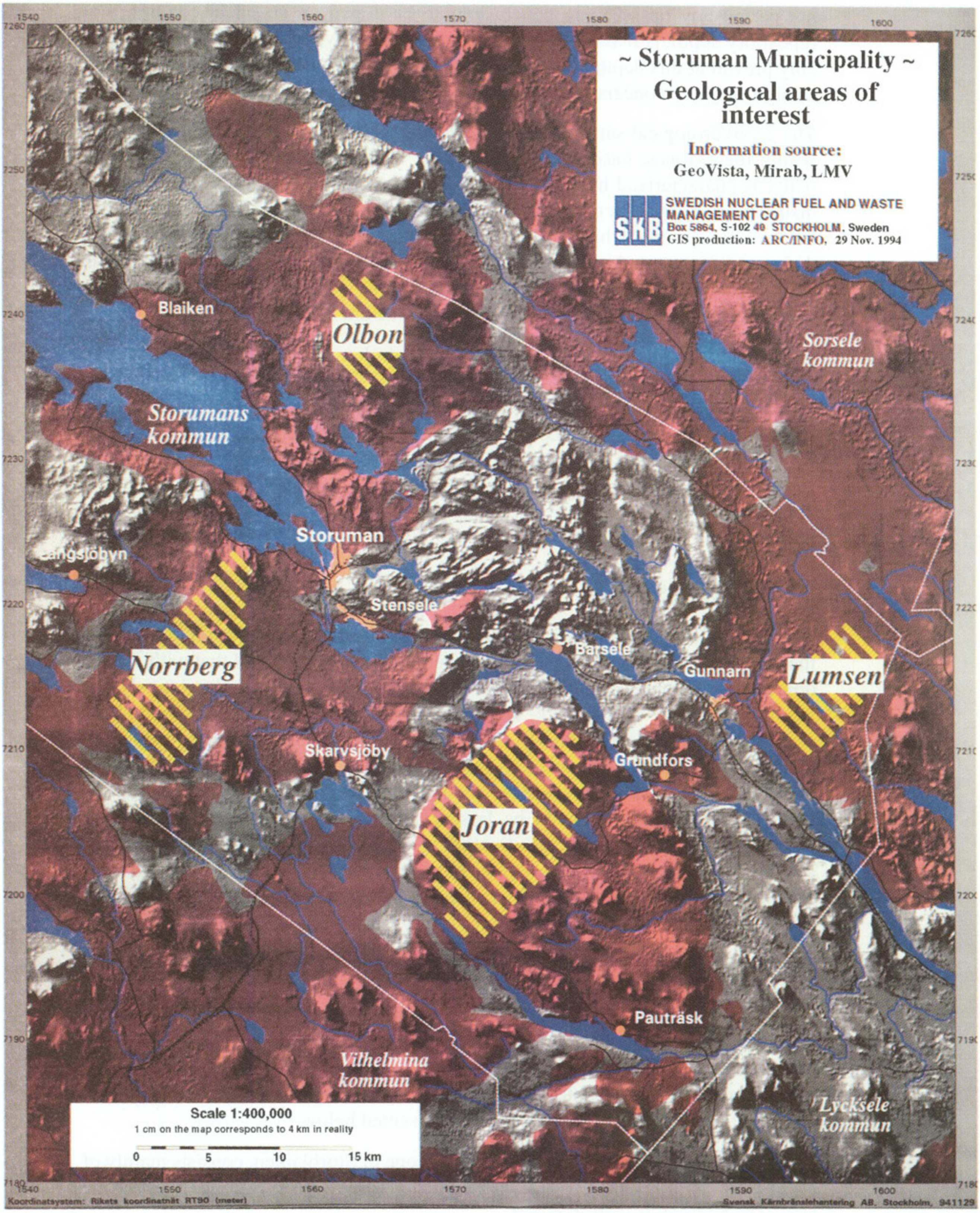


Figure 5-6. Studied areas (hatched in yellow). All studied areas lie within the municipality's granite areas (red). The map is based on rock type distribution data available at the start of the feasibility study.

portion of the Olbon area that may be suitable for further studies. The reconnaissance study further observes that the margin of the two-mica granite, about 3-4 km from the area, may be of interest for prospecting, and that granite with elevated uranium concentrations occurs at the western limit of the area.

The area is intersected by boulder-rich ravines with a high fracture frequency and spaced at intervals of about 1 km. According to the geophysical study, there are no electrical conductors between the boulder-rich ravines, which suggests fracture-poor bedrock /5-11/. The geophysical study further concludes that there are probably large volumes of bedrock with a low fracture content, but that uncertainties exist concerning the structure and extent of the granite, especially its extension to greater depth.

The western area, **Norrberg**, consists of ridges named Sabotsliden and Inre Verkanliden.

The rock type at Sabotsliden is hornblende granite. There is great variation in fracture frequency, and there may be flat-lying fracture zones /5-11/. Magnetic and topographical lineaments (possible fracture zones) occur at intervals of about 500 m.

According to existing maps the rock types at Inre Verkanliden consist of granodiorite/tonalite. However, exposed rock surfaces of diorite were encountered during field studies of the area's north and west side. Several exposed surfaces exhibit heterogeneous sections with fragments of foreign rock types (xenoliths), dikes and altered bedrock. The fractures contain, among other phases, sulphide minerals such as pyrrhotite and pyrite.

There is a copper-zinc mineralization just north of Inre Verkanliden, Näsvattnet, which has been studied on several occasions by NSG (the State Mining Property Commission). The mineralizations occur in boulders. The source rock for these boulders has not been found, despite trenching and coring. Another deposit, a small tungsten-zinc mineralization, exists outside the area towards the southeast, at Verksamheten.

Both the geological and the geophysical studies /5-11/ conclude that Sabotsliden and Inre Verkanliden are relatively highly fractured and heterogeneous areas. Prospecting interest exists in the vicinity of the areas.

The southern area, **Joran**, covers a number of ridges and intervening valleys from Barsele-Storberget in the northeast to Hästliden in the southwest. The soil cover is mainly thin, and there are large areas where the rock is exposed. Geologically speaking, the area lies in the large Joran dome, which consists of coarse porphyritic Revsund granite and which comprises a raised circular area with steep rims.

The Joran area is located in the western part of the Joran dome. The area is extensive (about 90 km^2), which makes it the largest of the areas of interest, but is still just a portion of the total area of the Joran dome (about 300 km^2). According to lineament interpretations and geophysical studies, the eastern part of the dome has a higher frequency of fracture zones. The eastern part also contains small tungsten mineralizations which could possibly be of interest for prospecting /5-8/.

Most of the Joran area has a normal level of natural background radiation for granites. But there are also sections with elevated radiation levels, which may indicate a more complex formation of the granite than can be deduced from other observations and measurements. The highest uranium concentrations occur at the margins of the granite dome /5-13/.

The granite gives rise to anomalous low gravity values due to the fact that it has a lower density than its environs. This can be utilized to make a rough estimate of the depth of the granite. Calculations indicate that the granite within the Joran area is at least 0.5 – 1 km deep, probably 1-2 km /5-11/.

The Joran area is intersected by a pronounced W to NW-trending valley in which the lakes Inre and Yttre Joranträsket are located. This valley presumably represents one or more major fracture zones. Interpretations of fracture zones from topographical maps or electrical aerial surveys suggest that fracture zones in general occur at intervals of 1-2 km and 2 km, respectively /5-11/.

The geological field study showed that the entire Joran area consists of one and the same grey-to-reddish-grey coarse-porphyritic granite. No dikes were found, and the fracture frequency was low in studied exposed rock surfaces.

The eastern area, **Lumsen**, is situated east of Gunnarn and consists of two subareas, Lumsberget and Lycksaliden, both characterised by Revsund granite.

Lumsberget is a relatively small mountain with steep slopes. Different types of granite were encountered during the field study. Lumsberget's heterogeneity, in combination with the fact that it is surrounded by major fracture zones near the Ume River, makes the area less interesting for a deep repository.

The Lycksaliden-Mödakammen area is approximately 10 km^2 in size. The area consists of a poorly defined ridge where the degree of exposure is generally low but where small outcrops occur in ditches, along with some larger areas of exposed rock. At certain places the glacial till is more than 5 m deep. A rough assessment based on the field reconnaissance study suggests that the area consists primarily of homogeneous granite with a low fracture content. Other rock types (gabbro, diorite, shale xenoliths in granite) were found at the outer limits of the area.

At Lycksaliden, radiation measurements indicate consistently low values. Based on topographical lineaments, fracture zones occur at intervals of about 1 km.

Both the geological and the geophysical surveys /5-11/ conclude that good prospects may exist for further studies in the area around Lycksaliden, but that uncertainties exist regarding the homogeneity and depth of the granite. One question is whether there is a neotectonic fault at Juktån, about 4-5 km northwest of Lycksaliden. If so, it may extend towards the areas at Lumsen.

5.8 PROSPECTS WITH RESPECT TO LONG-TERM SAFETY

Criteria/factors

In order to make it worthwhile to continue investigations in Storuman Municipality, it must be judged likely that there is a site that meets stringent environmental and safety requirements.

A feasibility study cannot conclusively determine that a site in a municipality meets the safety-related requirements for a deep repository. This necessitates a long process of increasingly detailed investigations from the surface, and at depth from boreholes and tunnels. In a feasibility study, when borehole investigations are lacking, the work therefore has to be concentrated primarily on identifying and analyzing geoscientific conditions that may be unsuitable or unfavourable based on generally available information. Conditions that should be avoided are, first and foremost:

- highly heterogeneous and difficult-to-interpret bedrock;
- rock types of interest for mineral extraction or other exploitation;
- known deformation zones and neotectonic faults;
- pronounced discharge areas for groundwater;
- abnormal (for Swedish bedrock) groundwater chemistry.

Conditions that are sought after in the choice of areas for further studies are:

- ordinary rock type with large extent;
- few major fracture zones;
- high degree of exposure or thin soil cover.

As is discussed in Chapter 3, a more reliable assessment of long-term safety can be made when borehole data are available. Then the suitability of an area can be judged on the basis of criteria relating to the chemistry of the groundwater, the hydraulic conductivity of the bedrock, flow paths for the groundwater, the mobility of any radioactive substances dissolved in the groundwater, the stability of the bedrock, etc. Until then, the suitability of an area has to be judged with the aid of the aforementioned somewhat generally formulated criteria/factors. A general description of environmental impact over very long timescales is given in section 8.4.

Storuman Municipality

Based on the aforementioned criteria/factors, the following can be noted:

- the central and western part of the municipality should be avoided, since it consists of Caledonian bedrock, which is less suitable for a deep repository owing to its heterogeneity;
- there are areas of interest for prospecting in the eastern part of the municipality;
- a major regional deformation zone may occur along the valley of the Ume River;
- large rock movements in conjunction with the retreat of the continental ice sheet, known as neotectonic faulting, may have occurred north of Gunnarn. However, further investigations are required to verify whether this is the case;
- the valley of the Ume River is a pronounced discharge area for groundwater;
- no data on abnormal groundwater chemistry have been obtained.

This leaves several rather large granite areas, four of which have been studied in greater detail than other parts of the municipality. Based on what has been found in these studies, and the field reconnaissance, the following conclusions can be drawn regarding their potential for further studies. A collective assessment in which land and environment factors are also included is provided in Chapter 11.

The **Olbon area** at Blaikfjället and the **Norrberg area** are more heterogeneous than was indicated by the existing geological maps. Even though this does not have to be negative for a deep repository, it increases uncertainty regarding how conditions are at greater depth. Both areas lie close to bedrock of interest for prospecting.

The granite in the **Lumsen area** at Lycksaliden is probably homogeneous and has a large extent. But its degree of exposure is low, which means that more investigations are required before this can be verified. An important question is whether any large rock movements have occurred in some fracture zones north of Gunnarn towards the end of the last ice age. If this is the case, these zones may extend down towards the Lumsen area.

The **Joran area** is relatively well-exposed. The granite is homogeneous and has a relatively low content of fractures and fracture zones. The area is large, about 90 km^2, which allows great freedom in the siting of an approximately 1 km^2 large deep repository. The homogeneity of the granite and the high degree of exposure should provide good opportunities in a site investigation for making a good assessment of the bedrock in terms of constructability and long-term safety.

The above judgements are preliminary and based on general studies. If a decision is made to proceed with further investigations in Storuman municipality, more in-depth geological studies will be conducted. If this is planned, local residents, landowners, Sami (lapplander) community and other concerned persons will be informed well in advance before the investigations begin. Ample opportunity will exist to influence the execution of the investigations so that any disturbance and inconvenience is minimized.

6 FACILITIES IN CONJUNCTION WITH THE DEEP REPOSITORY

This chapter describes how the deep repository can be designed, how the activities at the deep repository will be conducted, what tasks will be performed and how many people will be employed. The information is preliminary. The chapter is concluded with a description of experience from rock facilities in Storuman.

6.1 GENERAL

The following description of the facilities at a deep repository and how they will be constructed, operated and closed is based on the principles that have been worked out in KBS 3 /6-1/ and RD&D-Programme 92 /6-2/, plus SKB's plan report /6-3/. A schematic description of a deep repository is provided in Appendix 1.

Ongoing and planned research, e.g. in the Äspö HRL, will provide further support material for a more detailed design of the deep repository. The geometric layout of the deep repository on a given site will also be adapted to the properties of the bedrock on the site and to the conditions on the surface. The final facility design may therefore differ from the description given below.

6.2 CONSTRUCTION AND OPERATION

The deep repository will be built in two stages. In the first stage, approximately 400 of the total approximately 4,500 canisters of spent nuclear fuel will be deposited. It is estimated that this initial operating period will start in 2008 and last for about 5 years, after which the experience gained will be evaluated by SKB and the regulatory authorities. It will be possible to retrieve the canisters if this should be deemed necessary for any reason.

If the outcome of the evaluation is favourable, the rest of the repository will be built (stage 2) and operations will continue until all waste has been deposited, which will occur around the year 2040. The total quantity of spent nuclear fuel which will then have been deposited is estimated to be about 8,000 tonnes, which is the quantity produced by the Swedish nuclear power programme up to the year 2010.

Other radioactive waste will also be deposited in a special part of the deep repository during stage 2. The waste resembles that which is being deposited today in the final repository for radioactive operational waste, SFR, in Forsmark. A more detailed description is given in section 8.4. The total quantity of other waste is estimated at 20,000 m^3.

6.3 ACTIVITIES

The central activity at the deep repository is to receive canisters with spent nuclear fuel and to deposit (emplace) them in selected positions approximately 500 m down in the rock. During the regular operating period (stage 2), certain other radioactive waste will also be deposited in the deep repository.

Implementing this requires:

- preparations in the form of geoscientific investigations, tunnelling, blasting of rock caverns, boring of deposition holes, etc.;
- down-transport and emplacement of the canister and surrounding bentonite buffer in deposition holes;
- down-transport and emplacement of other radioactive waste in rock caverns;
- post-deposition work in the form of instrumentation, backfilling of deposition tunnels and rock caverns, inspection, etc.

The following facilities are needed at the deep repository to support this central activity:

- ventilation equipment;
- deposition system, machines;
- transport facilities (possibly rail terminal);
- reception station above ground;
- mechanical workshop;
- plant for stock-keeping and preparation of bentonite and sand
- buildings for office, admission control, canteen and information;
- plants for various utilities (ventilation, water supply, sewage).

6.4 SCHEMATIC DESIGN OF THE DEEP REPOSITORY

The repository will be built at a depth of 500 m. From the floors of tunnels at this depth, holes approximately 7.5 m deep and 1.6 m in diameter will be bored in which canisters with spent nuclear fuel will be emplaced and packed in bentonite clay. (See Appendix 1.) The canister has a length of about 5 m and a diameter of about 0.9 m. The tunnels can be backfilled with a mixture of bentonite and quartz sand.

The waste is deposited in three separate repository areas: an area for canisters that are deposited during the initial operating period (stage 1), an area for canisters that are deposited during regular operation (stage 2) and an area for other waste (stage 2). Altogether, these repository areas occupy an area of about 1 km^2. Figure 6-1 shows a schematic drawing of the design of the deep repository.

Surface facilities

Figure 6-2 shows a schematic layout of the surface facilities at the deep repository. In this example it is assumed that the facilities are built on a flat industrial site; in reality the facilities will be adapted to the topography of the site in question.

The surface part of the deep repository is divided into four main zones:

- rail yard;
- production zone;
- service zone;
- dumps for rock waste.

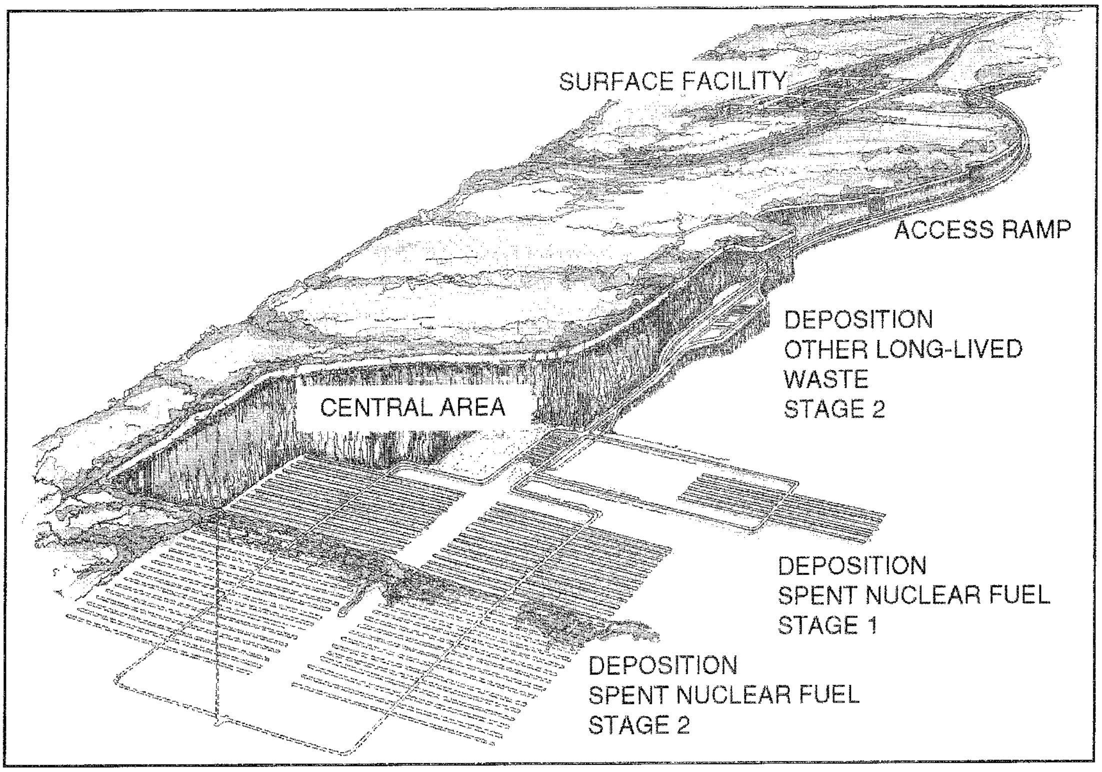
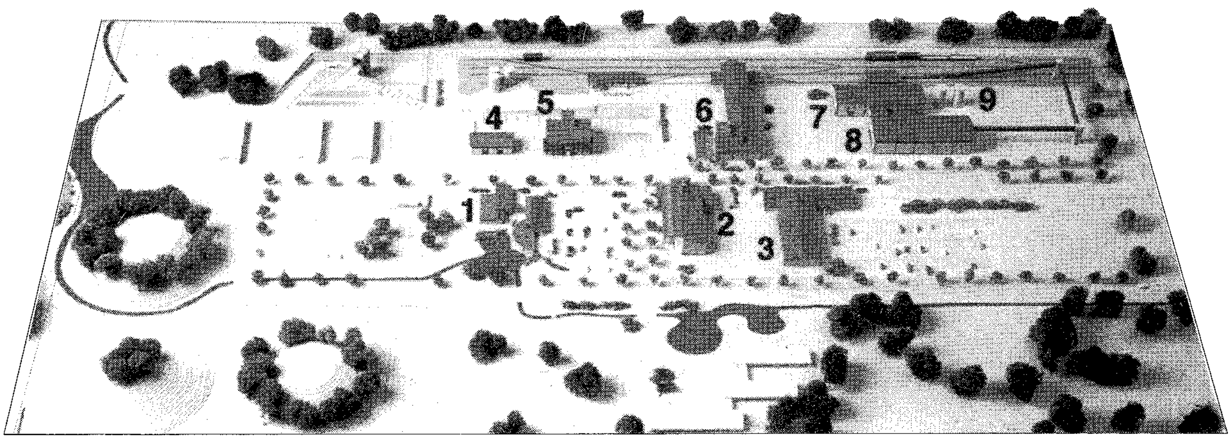


Figure 6-1. *Schematic design of a deep repository.*



1. Information and restaurant
2. Office and workshop
3. Personnel quarters, storeroom
4. Utilities building (water/heat)
5. Ventilation building
6. Operations building (reception/inspection of containers)
7. Production building (for bentonite blocks etc.)
8. Sand store
9. Bentonite store

Figure 6-2. *Schematic design of surface section of deep repository.*

When the backfill material and transport casks with the radioactive waste arrive by train, they will be taken into a rail yard where there are special facilities for unloading of transport casks, sand and bentonite. Owing to its length and the necessity of being flat, the rail yard will be govern the location of the surface facilities.

The production zone contains a transloading building for transport casks with waste, storage and production buildings for backfill material and buildings for ventilation, water supply and sewage treatment. The production zone also contains the access ramp or shaft leading down to the repository.

The service zone contains workplaces for many people such as offices, canteen, information building, maintenance and service shops, as well as a garage and facilities for the construction workers. This zone faces the access road and is a transition between the industrial site and the surrounding landscape.

Whatever rock waste are not used elsewhere they will be dumped near the facility and subsequently covered with till and planted with trees. Local conditions will determine the form of the rock waste dumps.

Underground facilities

The repository's underground facilities consist of a central area with ventilation building, workshops, personnel rooms, transloading hall for transport casks and tunnels for transport and deposition of canisters with spent nuclear fuel, plus rock caverns and tunnels for other waste.

Connection between surface and underground facilities

Transportation between the surface facilities and the repository level (approx. 500 m deep) can be designed according to three slightly differing alternatives:

- all goods are transported down a long, sloping ramp. The lateral offset between the surface facilities and the actual repository can be several kilometres in this case;
- all heavy and bulky goods are transported on a spiral-shaped ramp between the ground surface and the repository level. The shaft is mainly utilized for personnel transport and ventilation;
- all goods and personnel are transported between the ground surface and the repository level via a shaft.

In all alternatives, the repository is positioned optimally in relation to the geological conditions on the site. But there may be good reasons to offset the facilities on the surface in relation to the repository. Such an offset may, for example, be warranted by considerations such as nature conservation, reindeer husbandry, the local populace, municipal plans, but also technical factors such as ground conditions, connection to existing railway/road, etc.

6.5 HUMAN RESOURCE REQUIREMENTS

The number of employees and the competence profiles of the personnel will vary during the siting process and the course of the disposal operation. Only a few people will be employed during the initial investigations, after which the workforce will grow to a peak of around 600 persons during the most intensive construction period. A human resource requirement of around 220 persons is expected for the operation of the deep repository.

Site investigation

During site investigations the principal work operations will consist of drilling and borehole measurements, plus minor road construction. Site investigations are expected to take about 3 years and employ 10-20 persons, mainly drillers, technicians and researchers. Resources for road construction, maintenance, snow clearance etc. are required more or less continuously, while other activities will be required periodically.

Detailed characterization

During a detailed characterization, a ramp or a shaft is driven down to a depth of about 500 m. An access road is built and provisional arrangements made. Blasting of the underground facility's central section is begun. Transportation to and from the facility will mostly involve machinery, installation materials and personnel, as well as excavated rock waste.

Detailed characterization is estimated to take 4-5 years and employ 50-80 persons on the site. A large portion of the workforce will be engaged with rock excavation and other civil engineering work. The number of technicians and researchers is estimated to be about 15-20 persons. Personnel for maintenance, cleaning etc. will be needed.

Construction of deep repository and initial operation

After a decision is taken to construct the deep repository, an intensive construction phase will begin. At most about 600 people will be employed. Of these, approximately half will work on the actual deep repository and about half on the support infrastructure that is needed in the form of construction and improvement of harbours, railways and roads.

All ground work required to make the site, with its associated road system and rail yard, a fully operational facility will be carried out during this period. Connecting railway tracks will be laid and all buildings included in the surface facility will be built. At the same time, all rock caverns in the central portion of the underground facility will be excavated, along with deposition holes for about 400 canisters with spent nuclear fuel. Large quantities of building materials, machinery and equipment will be transported to the site during this period, while rock spoils will be removed.

Initial operation is expected to start in 2008 at the earliest. The tasks include transport, handling and deposition with subsequent backfilling of canisters and deposition tunnels. The initial operating period will last about 5 years and employ around 150 people.

Regular operation

Provided that a decision has been made to start regular operation, construction of the underground facility will proceed at the same time as waste is deposited. This means that construction will proceed throughout the operating life of the repository. Furthermore, the repository will be expanded to include transport and deposition tunnels and rock caverns for other long-lived waste. Regular operation will continue over a 30-year period.

Table 6-1. Examples of tasks at the deep repository during regular operation. These tasks will require a total of about 220 man-years.

Function	Activity
	Operation
Operations	Work planning, Preparation, Coordination, Management, Waste documentation, Access control, Radiation protection, Dosimetry, Control room function, Work instructions
Rock work	Tunnelling – rock haulage, Rock construction – rock reinforcement, Hole boring – deposition holes – test holes/core drilling
Deposition	Deposition tunnels: Preparatory work, Check of quality of deposition hole, Deposition work in deposition tunnels, Backfilling work
Harbour	Operation and administration, unloading/loading/maintenance
Railway	Shipments
Transport at deep repository	Unloading and temporary storage of waste, bentonite and quartz sand Waste canisters from temporary store above ground to mouths of deposition tunnels Other waste from temporary store above ground to repository for other waste Bentonite blocks from factory to deposition tunnels Bentonite-sand mixture from preparation plant to deposition tunnels Building materials, machine parts, consumables, waste, etc.
Service	Preventive maintenance, Repair of fixed installations, Repair of machinery
Rock dumping	Dumping of rock waste. Landscaping, Replanting
	Technology/maintenance
Plant documentation	Buildings, Systems, Machinery, Components
System technology	Design: mechanical, electrical, hydraulics, pneumatics, electronics for systems, equipment and machinery
Workshops	Qualified machining for heavy steel structures, Welding and forging, Electrical and Electronic work
Stores	Dispatching, Delivery recording, Internal distribution, Storeskeeping
Installation	Installation, installation inspection, Trial operation of contracted work
Maintenance	Lifts, hoists and overhead cranes
	Geotechnics
Rock docum.	Geotechnical data, CAD documentation
Geology	Mapping, Evaluation
Rock mechanics	Fracture surveys, Strength and stress measurements, Evaluation
Hydrology	Hydro-tests, Inflow measurements, Modelling, Evaluation
Chemistry	Sampling, Chemical analyses, Evaluation
Geophysics	Measurement, Evaluation
Surveying	Underground surveying, Map drafting, Location of boreholes
Drill cores	Drill core storage, Sample preparation
Geoinstruments	Instrument service, Instrument storage
	Staff functions
Information	Exhibit, Visit scheduling, Guiding, Local and international contacts
Quality	Quality control, Environment and permits, Occupational safety
Personnel	Salaries, Training, Fitness, Health care, Travelling expense account service
Accounting	Budget, Follow-up, Accounting, Invoicing, Invoice processing, Project accounts, Cash
Purchasing	Goods, Services
Office services	Porter, Tele-exchange, EDP, Repro, Records, Library, Office supplies, Furniture
Security	Authorization control, Site protection, Rescue service, Fire protection
Building serv.	Cleaning service, Road upkeep, Snow clearance, Surface haulage, Refuse collection, Building maintenance, Laundry
Food service	For own personnel, contractors, visitors

Operation of the facility will be overseen by a site organization. Some services will be purchased externally. The size of the workforce during this period is estimated at 220 persons, assigned to the tasks described in Table 6-1.

Qualifications

The job positions span a large number of tasks with varying requirements on educational background and work experience. The requirements range from primary school to advanced degrees and long professional experience.

To illustrate the needs for personnel with different educational levels during the regular operation of the deep repository, the tasks described in Table 6-1 have been assigned to three groups of personnel with different educations:

Primary or upper-secondary school	40%	of the total workforce
Vocational training	45%	-"-
University education	15%	-"-

The positions thus require some personnel with a university education, a large portion with vocational training (skilled work force), but also a considerable portion without any special professional training.

Recruitment

The staffing alternative – contracted or employed by SKB – has not yet been determined. But with today's experience from SKB's facilities it is likely that deep repository construction will be contracted out. Operation, on the other hand, might well be organized under SKB's own auspices.

Recruitment for repository operation must ensure that the personnel who are hired have the necessary basic knowledge and skills for the job. Internal training will be required, as in other branches of industry, so that the employee can learn about the company and the workplace, as well as the terms and rules that apply.

The most probable approach is that the deep repository will start by hiring a core of skilled individuals. Besides handling their regular jobs, these individuals will also be given responsibility for training less experienced colleagues. Experience from the mining industry indicates that once operation has got under way, recruitment takes place locally as far as possible.

The relative distribution of the jobs between men and women will be determined by how the desired qualifications are distributed between the sexes. Today, most of the tasks would be classified as belonging to typically male professions. However, this description is not specific to the deep repository, but rather reflects the general imbalance in society with few women in technically oriented professions. However, it should be possible, if deemed desirable, to target women specifically for recruitment and training. The tasks at the deep repository should be as suitable and attractive to women as to men.

6.6 SURVEILLANCE AND CLOSURE

The scope of surveillance and monitoring of the repository site can be determined by each generation independently. Closure involves backfilling and sealing of tunnels and shafts. The repository is designed so that it will remain safe over a very long period of time, even if surveillance and monitoring cease after closure.

Before the repository is sealed and closed, the canisters that were initially deposited will have been under observation for several decades. This will make it possible to ensure that everything works in the intended manner during the early surveillance phase. The initially deposited canisters can be retrieved and inspected prior to closure if further verification is desired.

After closure, the site will be restored as closely as possible to the conditions that existed prior to establishment of the facility. It will also be possible to build facilities for other activities on the site. There will not be any restrictions on the use of the site for other purposes, with the exception of deep drilling or construction of any other deep rock facility.

6.7 EXPERIENCE FROM ROCK FACILITIES IN STORUMAN

There are several underground rock facilities in the municipality. They provide an idea of the rock construction-related conditions on the sites where the facilities are situated. Experience gained from these rock facilities therefore serves as random samples in support of judgements of how such factors as rock quality and groundwater inflow to the tunnels vary between different rock types and in different parts of the municipality. The feasibility study has compiled the experience gained from the hydropower plants in Juktan, Umluspen and Grundfors and a number of defence facilities /6-5/, /6-6/. In must be borne in mind that most of these facilities have not been built on a given site because the rock was particularly good there, but because the facility was needed at that particular location. It should be further noted that most of the facilities are situated at a depth of less than 100 m, whereas a deep repository will be situated at a depth of about 500 m.

General experience shows that high and widely varying rock stresses often occur in the Caledonian rocks (main rock component of the Swedish mountains) or in the crystalline basement rock immediately adjacent to the Caledonian bedrock. High rock stresses have in some facilities caused rock construction-related problems. However, there is nothing to indicate that these disturbances occur at any great distance (several tens of kilometres) from the Caledonian front /6-5/. Nor does the information gained from the studied facilities in Storuman Municipality indicate rock stresses that are high or abnormal in any way. There are, however, examples of elevated rock stresses occurring in fracture-poor granites at various places in the world, and that they can in this environment give rise to poorer stability around tunnels, which necessitates more rock reinforcement, thus increasing costs and the complexity of the construction work.

The Juktan tunnels have become famous for the very high water inflows that occurred during the construction phase. The largest water inflows were associated with a few distinct fracture zones. Approximately 80% of the total inflow came from seven fracture zones /6-6/. The driest sections in the tunnel system were found in the tailrace tunnel between the power station and Mellansänket, where sections with a length of a few kilometres were in a practically sense completely dry. These sections coincide with the thickest rock cover (200-400 m). The biggest construction-related problems encountered during the Juktan project occurred whilst intersecting the major fracture zones. The poor rock quality there required extensive reinforcement measures.

The general conclusion from the Umluspen and Grundfors hydropower stations is that they exhibit good rock construction-related conditions, despite the fact that they are situated within the wide regional fracture zone that follows the Ume River

(Figure 5-4). The principal rock type at the two stations is Revsund granite. No tendencies towards weathering of exposed rock surfaces have been noted during the 35 years the stations have been in use. Water inflow into the facilities is small. The defence facilities in the area also confirm the picture of normal rock conditions.

6.8 PROSPECTS WITH RESPECT TO ROCK CONSTRUCTION AND OPERATION

Criteria/factors

The bedrock conditions on the site must allow construction of stable shafts, tunnels and rock caverns so that safety requirements during construction and operation are met.

Storuman Municipality

Experience from existing tunnels and rock caverns in the municipality have not given evidence of any abnormal rock construction-related conditions. At the same time, this experience must be regarded with caution, since there are only a few facilities and they are located nearer the surface than is planned for a deep repository (the Juktan tunnel is an exception here).

Generally, the granites in the municipality are judged to offer good construction-related conditions. One question which the feasibility study has not been able to answer is whether abnormally high rock stresses occur at repository depth in the fracture-poor granites. Such conditions can give rise to reduced stability around tunnels, which in turn requires more rock reinforcement and thereby increases the costs and complexity of the rock construction work.

The bedrock can at certain places give rise to radon concentrations in rock caverns that may require special engineering solutions. (See Chapter 9.)

Possible further studies will include measurements of radon concentrations and rock stresses in deep boreholes and a general assessment of constructability in the studied area.

7 POSSIBLE TRANSPORT MODES AND TRANSPORT ROUTES

The spent nuclear fuel is being stored temporarily, prior to final disposal, at CLAB, located in Simpevarp in the municipality of Oskarshamn. If a deep repository is built in Storuman, encapsulated spent nuclear fuel, along with other long-lived radioactive waste, will be shipped to it for final disposal. However, the largest quantities of transported materials will consist of sand and bentonite clay for backfilling around canisters and in tunnels. This chapter gives an account of some possible harbours and transport routes for all these types of cargoes. Safety in conjunction with shipments of radioactive waste is discussed.

7.1 GENERAL

Transport routes for radioactive waste and backfill materials to Storuman are described in the feasibility study's transport report /7-1/. In addition, there is a study that gives a general account of suitable transport modes for different types of cargoes to be shipped to a deep repository /7-2/. A summary is given here of these two reports, with an emphasis on shipments of radioactive waste. The purpose of the feasibility study's transport report has been to investigate and evaluate possible harbours and transport routes, as well as to identify any needs for new construction of transport lines, transloading stations, etc. The intention has been to describe some possible transport modes and transport lines; a full appraisal is not presented. The transport steps from the encapsulation plant to the deep repository are shown in Figure 7-1.

7.2 TRANSPORTATION SYSTEM AND CARGO TYPES

The transportation system shall be reliable and able to operate all year round, and must be able to handle two main types of cargoes, namely heavy units containing encapsulated fuel and other long-lived waste, and bulk cargoes in the form of sand and bentonite clay.

The heavy units are specially designed transport casks for encapsulated fuel and similar containers for concrete moulds containing other waste. The total number of units to be shipped to the repository each year is estimated at about 310. The casks and containers will be shipped back for refilling after being emptied.

The bulk materials consist of about 45,000 tonnes of sand and 15,000 tonnes of bentonite clay per year. The bentonite shall provide mechanical protection around the canisters and counteract water movements in the deep repository. According to present-day plans, the deposition tunnels shall be backfilled with a mixture of bentonite and quartz sand. Other materials are also being considered.

7.3 SHIPMENTS OF RADIOACTIVE MATERIAL

Table 7-1 shows how many transport casks/containers filled with encapsulated fuel and other waste will be shipped to the deep repository, provided that all reactors are

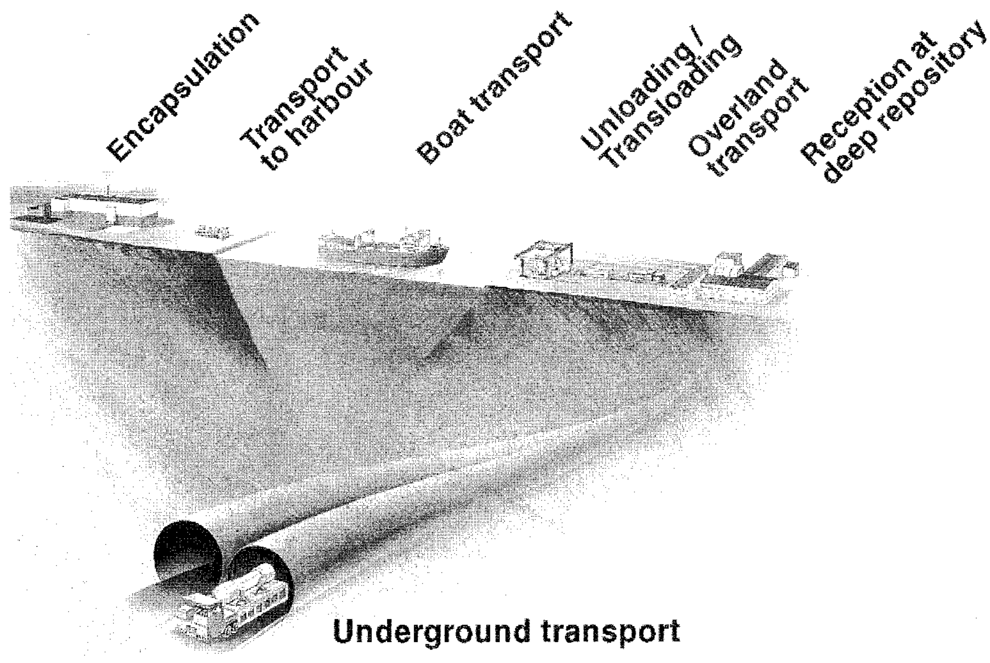


Figure 7-1. Modes of transport from the encapsulation plant to the deep repository. In this figure it is assumed that a sloping tunnel, or ramp, is used for transport from the aboveground portion of the deep repository to the underground portion.

kept in operation until 2010. Only canisters with spent nuclear fuel will be deposited during the initial operating period in the deep repository (stage 1). Both spent fuel and other long-lived waste will be deposited during regular operation (stage 2).

Table 7-1. Estimated number of shipments of casks/containers with encapsulated spent nuclear fuel and other long-lived waste to the deep repository.

Waste unit	Total quantity	Per year
Spent nuclear fuel		
– copper canisters (initial operation)	400	100
– copper canisters (regular operation)	4,000	210
Other long-lived waste (regular operation)	2,000	100

Encapsulated spent nuclear fuel

Spent nuclear fuel is a solid ceramic material that is enclosed in metal tubes ("cans") of a zirconium alloy. The fuel-can elements are called fuel rods. A batch of fuel rods held together is called a fuel bundle or assembly. In the encapsulation plant that is planned to be built in connection with CLAB, the fuel assemblies will be enclosed ("encapsulated") in highly durable canisters. A filled canister weighs about 15 tonnes, is about 5 m long and has a diameter of about 0.9 m. The outer part of the canister wall consists of 5 cm of copper and the inner part consists of 5 cm of steel. The canisters are hermetically sealed and the risk that radioactive substances will leak out during handling or transport is virtually non-existent. However, some radiation does penetrate the canister walls, which is why the fuel canisters must be transported in radiation-shielded casks in order to protect the environment.

The transport casks that are used today for shipments between the nuclear power plants and CLAB are designed for carrying spent fuel that has been stored for a number of months after discharge from the reactor. The shipments to the deep repository will carry 30-40 year-old fuel whose radioactivity is about 10% of what it was when it arrived at CLAB. Moreover, it is enclosed in a canister during transport to the deep repository. All in all, this means a lower radiation level and lower heat generation compared with today's shipments, permitting the design of the casks to be modified accordingly. A transport cask with canister is estimated to weigh about 55 tonnes.

Other radioactive waste

Core components and other waste with long-lived radioactivity resulting from the operation and decommissioning of the nuclear power plants, the encapsulation plant and the Studsvik reactor is also planned to be emplaced in the deep repository. A description of this waste is provided in section 8.4. Most will be embedded in concrete moulds. This waste type also requires some radiation shielding and is therefore transported in steel transport containers weighing 65 tonnes, including waste. The total quantity of other radioactive waste to be deposited in the deep repository is estimated to be about 20,000 m^3.

The purpose of the transport casks/containers is to shield off the radiation to such a low level that they can be handled without any special protection during loading and unloading of ships, vehicles and trains. The casks and containers must also be able to withstand severe external stresses. This means that the transportation system does not have to be designed to provide additional mechanical protection to the cargo. Nevertheless, the casks/containers with contents are classified as dangerous goods according to international regulations and must be marked, separated and kept under surveillance in accordance with the regulations that apply to radioactive goods.

7.4 SHIPMENTS OF BACKFILL MATERIALS

Bentonite clay is exported from many countries, including the USA and the Mediterranean region. The material is sensitive to moisture and must be kept dry and protected against contamination during transport and storage. Bentonite can be transported in bulk form, i.e. unpackaged in special bulk containers. The need amounts to approximately 18 containers per week for an average of 40 weeks per year.

Quartz sand with the right quality can be delivered from the southern Baltic Sea, among other places. Ordinary bulk freighters can be used to ship the sand to the local harbour. The need is about 45,000 tonnes, which shipped in consignments of 4,500 tonnes amounts to about 10 shiploads per year. Since the backfill materials are shipped in large consignments, temporary storage facilities are needed at the harbour.

7.5 TRANSPORT MODES AND TRANSPORT ROUTES

Ship transport

The transport casks/containers are filled with canisters/moulds and sealed at the encapsulation plant at CLAB. They are then placed on carrier frames designed for use both on board the ship and on railway cars or road vehicles. The casks are loaded onto the ship in the same manner as today by special terminal vehicles.

The annual quantity of 310 casks/containers corresponds to 31 round trips, if the ship (as today) has 10 positions for casks/containers. The trip from CLAB to a harbour in the northern part of the Gulf of Bothnia takes about two and a half days at a speed of 10 knots without ice hindrance. The round trip can be carried out in less than 6 days under ice-free conditions.

Since the ship will be heavily ice-reinforced, she will be able to call at northern Swedish harbours year-round, with icebreaker assistance. However, under normal to difficult ice conditions in the Gulf of Bothnia, the sea voyage can take twice as long as normal. On an annual basis, it is therefore estimated that the average journey will take 8–8.5 days. The ship will then be occupied for 260-270 days a year carrying transport casks and containers to the deep repository.

When the ship has docked, the casks and containers are driven ashore on their carrier frames and "parked" alongside railway tracks or vehicle places. The casks/containers are lifted by special lifting devices and secured on the railway cars or road vehicles. Empty casks/containers are taken back on board and secured for the return trip.

Harbours

The harbour is either a designated terminal in an existing port or a local harbour built for receiving shipments to the deep repository. It is equipped with driving ramps, railway tracks, lifting devices for casks/containers, handling and storage equipment for the bulk cargoes, parking spaces for vehicles and carrier frames, and the necessary control and safety equipment.

Since the purpose of the feasibility study is restricted to identifying some possible transport routes, the number of harbours in the study has been limited to three: Skelleftehamn (the harbour in Skellefteå), Umeå outer harbour (Holmsund) and Hörnefors, see Figure 7-2. Skelleftehamn and Umeå are active industrial harbours, while Hörnefors was previously a local harbour for a pulp mill that is now closed.

Both Skellefteå and Umeå have areas suitable for the purpose. These areas do not have ready-made quays or storage areas, but they are served by roads and railway tracks. Both locations have navigable entrance channels, are open in the winter and have other public services. Both Skelleftehamn and Umeå outer harbour have railway and road links permitting further transport to Storuman, see Figure 7-2.

The harbour at Hörnefors can be improved with additional quays and storage areas. From here there is a road link to the motorway. There may be a rail link to Umeå if and when the new Bothnia railway is built.

All harbours have sufficient capacity to handle the additional ship traffic that would be generated by shipments to the deep repository. Winter ice conditions will not seriously impair operation, judging from today's icebreaker capacity.

Further transport from harbour to the deep repository

Transport from the harbour to the deep repository will take place by rail or road. Since trailers for road transport and railway cars will be specially deployed for the transportation system, the availability of adequate cars or trailers and empty return casks/container is always assured when the ship arrives in port, so that waiting and storage of full casks/containers in the harbour is avoided.

Since the transport cask/container with contents is heavy, the bearing capacity of the roads and the railway is of great importance both for passability, and thereby the ability to maintain a reasonably high speed, and for transport economy.

The fundamental technical difference between rail and road transport is that a railway is built for higher axle loads and that the load can be distributed over a larger ground area. This fact is reflected in the bearing capacity requirements for the National Rail Administration and the National Road Administration, where the railway today permits an axle load of 22.5 tonnes, with the goal of achieving 25 tonnes. Rail car weights well above 100 tonnes are permitted on many sections of railway. On public roads, an axle load of 11.5 tonnes and a total weight of no more than 60 tonnes are permitted on the best sections today. Heavier loads can be permitted after a dispensation procedure, and transport of 100 tonnes have been permitted on occasion along some of the studied road sections.

The survey of transport conditions /7-1/ notes that transport by rail from a harbour to Storuman Municipality of waste casks/containers could take place today without any significant restrictions from both Skelleftehamn and Umeå outer harbour. Road transport is also possible from the three harbours, but subject to limitations of both cargo quantity per vehicle and average speed.

The conclusion is that the combination of sea transport to a local harbour followed by railway transport to Storuman is judged to be the most likely alternative. The present-day railway network in northern Sweden is illustrated in Figure 7-2.

The areas in Storuman that have been judged to be interesting for further studies are not currently served directly by rail or adequate road connections. This means that a new road/railway must be built to the deep repository's industrial area. The length of the connection is about ten kilometres. To avoid having to transship from one type of vehicle to another, it is an advantage if the same transport mode can be used as on the section leading up to the municipality. Wide possibilities exist for routing the connecting road/railway to make allowance for both technical and environmental considerations.

Depending primarily on the terrain conditions and the distance from an existing road or railway to the deep repository, however, it may prove to be advantageous or less costly to switch transport means prior to the final leg. This would require transloading in a special terminal equipped with lifting devices and other technical aids to transfer the transport casks/containers between the vehicles. Furthermore, the terminal must contain a railway siding and parking areas for vehicles so that train sets and vehicles do not block other traffic on the regular transport line.

Figure 7-2. Studied local harbours and railway network for northern Sweden in relation to Storuman Municipality. The spent fuel is stored temporarily in CLAB, where encapsulation is also planned to take place.

7.6 EXPERIENCE

SKB's present-day system for sea transport has been in use since 1982. Some 80-100 casks of spent fuel have been transported annually to CLAB since 1985, and roughly an equal number of transport containers of radioactive operational waste have been transported annually from the nuclear power plants to the final repository for radioactive operational waste, SFR, in Forsmark. Experience from these shipments is good. No disturbances or accidents of safety-related importance have occurred /7-3/.

Few overland shipments of spent nuclear fuel and other high-level material have been carried out in Sweden. But such shipments are common in other countries, such as the UK, France, Germany and the USA. The UK has experience of approximately 180,000 cask-kilometres on road and rail. The American shipments go exclusively by land and have had a level of around 300 casks per year for the past twenty years or so. No accidents of safety-related importance have occurred /7-3/.

7.7 SAFETY

General about the safety of the shipments

Ensuring safety during transport between the encapsulation plant and the deep repository is mainly a question of doing the following:

- the risk of accidents and incidents occurring during transport shall be minimized;
- if an accident of some kind nevertheless occurs, it must not cause any release of radioactive materials to the environment;
- the radiation levels on the outside of the transport casks/containers shall lie below the limit values so that they can be handled without risk to the personnel.

By achieving these goals, it is ensured that the radioactive waste shipments will not pose any threat to the environment, either in the vicinity of the repository or along the transport routes that are used.

Similar shipments that occur today are characterized by very high safety in these respects. As mentioned above, no accidents of any radiological importance have occurred.

Three laws govern shipments of radioactive material in Sweden today: the Act on Transport of Dangerous Goods, the Act on Nuclear Activities and the Radiation Protection Act. A large number of regulations have been issued under these laws stipulating what permits are needed and what safety requirements must be met. These regulations are largely based on rules arrived at and agreed on internationally.

The Act on Nuclear Activities sets forth what information must be reported to and permits obtained from the responsible authorities before the activities begin. The Act on Transport of Dangerous Goods contains provisions governing transport by sea, land and rail /7-4/. Transportation to the deep repository shall be designed and executed in compliance with applicable laws and regulations.

Shipments to the deep repository

In shipments to the deep repository the solid radioactive material will be contained, first in canisters or moulds and then in very robust transport casks or containers. This will provide additional protection compared with today's shipments of spent fuel, which are not encapsulated. There is no known mechanism that could release the radioactive material, even if an accident should occur with the casks/containers during transport.

The transport casks and containers are designed in accordance with the requirements set up by the UN's International Atomic Energy Agency, IAEA. They are designed to protect the enclosed canister against damage while simultaneously shielding off the radiation emitted from it so that the cask can be handled safely during loading and unloading. The strength of the casks/containers is such that they can resist forces in excess of those that could occur in connection with conceivable accidents, such as collisions and falls, without breaking apart. What is important in an accident situation is that the radiation-shielding capacity of the cask/container is largely retained, in other words that the 40-50-tonne steel body remains intact around the enclosed waste.

No measures will or need to be adopted with the transport casks and containers beyond lashing on loading, unloading and transloading. Since the casks/containers are designed so that the radiation levels on the outside of the casks/containers is within legal limits, and that the time required for handling is fairly short, the total radiation dose to the handling personnel can be kept at a safe level. Experience from today's transportation system for spent fuel to CLAB shows that this goal can be achieved: The crew of the ship M/S Sigyn, which is used for this work, has not received doses in excess of the normal background radiation doses received by the public in general. (See Chapter 9.)

Planning and organization

The system for planning and execution of the shipments that is used today has proved to work well, and it is therefore natural to assume that the shipments to the deep repository will be organized in a similar fashion. It is thereby of minor importance that the deep repository shipments involve a longer overland transport distance than today's shipments, since the important safety-related factors, in terms of both organization of the shipments and their technical execution, is the same regardless of transport mode. Even though radioactive goods are not transported by road or rail to any appreciable extent in Sweden today, other dangerous goods are transported, so a successful protocol already exists for rail and road traffic.

Transport planning consists firstly of long-range planning for a year or so ahead to ascertain the need for transport resources, and secondly of detailed planning for each shipment, as regards size, time schedule, etc. The plan is notified in good time to those handling the shipment, as well as responsible authorities and local bodies.

Communication and physical protection

Part of the safety in the shipments is the physical protection which is aimed at preventing theft or sabotage of the casks/containers. It consists of a combination of engineered and administrative measures which protect the cargo and provide for detection and alarm if anything abnormal occurs. The measures include guarding, communication with a transport command centre and the like. Some information regarding how this system is designed is confidential to reduce the risk of sabotage. There is, however, no secrecy regarding how transportation is carried out.

For today's sea shipments there is a transport centre that tracks SKB's shipments with the M/S Sigyn. In the event of an accident or an incident at sea, the transport centre is informed. If there is danger to human life, the commander of the vessel notifies the nearest coastal radio station, which sends an alarm to the Swedish Lifeboat Service. The transport centre contacts those agencies that may need to provide assistance, if there is a risk of damage to or loss of a transport cask/container. The shipping line notifies the Marine Surveying Department, insurance companies and classification societies. If the ship needs assistance, measures are taken in consultation with the Marine Surveying Department.

The function of the transport centre in conjunction with rail and road shipments can be expected to be roughly the same as for sea shipments. In the event of an accident or incident, the transport leader on duty contacts the transport centre, which contacts the agencies whose assistance may be needed, such as the local police and rescue service. The radiation protection inspector on duty at SSI is also contacted. Written instructions accompany the shipment as to what measures should be adopted in different situations. There will also be a plan for how transport casks and containers can be salvaged along different sections of the route if the ship is unable to continue by its own engines.

Emergency plan

The emergency preparedness organization, which includes the local police and rescue service and the concerned county administrative board, is intended to enable these agencies to proceed efficiently if something abnormal occurs. To facilitate this, information on the transportation system shall be given to these agencies before shipments to the deep repository begin. SKB (who is in charge of the execution of the shipments) is responsible for ensuring that this information is correct and available, while public agencies are responsible for their own planning.

The local authorities will be kept continuously informed of the shipments planned for the immediate future. No active participation on their part during normal shipments will be required, however.

The emergency plan shall contain information on what should be done in the event of an accident along the transport route and what contacts should be made with authorities or other experts who might assist in making sure that correct measures are taken. It is important in an accident situation that correct information can be furnished, since overreaction may cause more harm than the event in itself. As mentioned above, there is no possibility that an accident could cause any major release of radioactive substances to the environment. Nevertheless, persons knowledgeable in the field of radiation protection may be needed on the scene to determine whether there are any elevated radiation levels before e.g. shipwrecked casks/containers on railway cars are salvaged, and if so to make sure that suitable shielding measures are taken.

As noted above, the planned shipments to the deep repository are not expected to lead to any impact on either the public or the environment. The permits that are required for the execution of the shipments must be on hand before the transport activity is commenced.

7.8 PROSPECTS WITH RESPECT TO TRANSPORTATION

Criteria/factors

The shipments shall be executed in such a manner that the safety requirements are complied with.

It is advantageous if an existing infrastructure for sea and land transport can be utilized.

It is disadvantageous if extensive new investments are required and if new harbours, roads or railways come into conflict with other important land-use interests.

Storuman Municipality

The surveys concerning transportation to a deep repository in Storuman show that:

- Skelleftehamn and Umeå outer harbour will be similarly well-suited as harbours for shipments of waste casks and containers to Storuman after construction of a new terminal;
- rail transport is possible today from each of these harbours to the deep repository's rail terminal in Storuman Municipality;
- Hörnefors can be utilized for the shipments, but only after extensive investments in both the harbour basin and quays and construction of a rail connection;

- road transport is possible from all three harbours, but with important limitations, both today and probably also when traffic would commence;
- shipments to a deep repository will not result in capacity problems on the transport lines, neither railways nor roads;
- areas of interest in Storuman are situated within ten or so kilometres of existing rail lines or adequate roads, which can be considered to be relatively favourable in this context;
- extensive experience exists of shipments of radioactive waste comparable to the shipments that may be made to Storuman. The shipments are not expected to result in any other risks to the public than those that are always associated with shipments of heavy goods.

In the event of continued studies in Storuman, an environmental impact assessment shall be carried out for shipments to the area in question. In addition to Storuman Municipality, those municipalities located along the transport route are also affected. They must therefore be given an opportunity to follow and participate in the work with the environmental impact assessment.

8 EFFECTS ON LAND USE AND THE ENVIRONMENT

This chapter describes possible effects on land use and environment caused by construction, operation and closure of the deep repository. The current situation in the municipality is described to start with, followed by the environmental effects that can be expected from a deep repository. In conclusion, the suitability of the four geoscientifically interesting areas is discussed with respect to their impact on land use and environment.

8.1 INTRODUCTION

A deep repository is a facility that can be designed with minimal environmental impact compared with what is normal for an industrial enterprise. There is no industrial process, there are few chemicals in use, and the backfill materials – quartz sand and bentonite clay – do not contain any polluting substances.

What is unique about the deep repository is that it will contain large quantities of radioactive materials. All measures in the deep repository system are aimed at keeping the radioactive materials isolated for very long periods of time. A central question is how safe this isolation can be made. This is analyzed thoroughly in safety assessments, where the long-term performance and safety of the repository is judged on the basis of a very broad body of scientific evidence. Safety assessments specific for a given site cannot be carried out until data are available from repository depth on this site. Such data are obtained from site investigations including deep drillings and measurements from the surface and in boreholes. Consequently, this report only gives a general description of long-term safety based on evidence from analyses of general data typical of Swedish bedrock.

One question which worries many people is what risks to human beings and the environment are posed by the radioactive waste in the short-term perspective, i.e. in connection with the waste shipments and deep repository operation. This is described in Chapters 7 and 9. Suffice it to say here that the spent fuel is hermetically sealed in canisters and these are in turn transported in sealed transport casks from the encapsulation plant to the deposition tunnel in the deep repository. The risk of radioactive materials escaping is virtually non-existent, even if the transport cask should be damaged.

A deep repository constitutes a medium-sized industrial enterprise, and even though the conventional, non-radiation-related environmental effects are relatively small, they will lead to effects on the environment, which are described in this chapter. The content of the chapter is a summary of two reports, /8-1/ and /8-2/.

A detailed environmental impact assessment (EIA) will be presented with SKB's application for a permit under the Natural Resources Act to begin a detailed characterization of a site. This will include an assessment of the repository's long-term safety on the site in question. The EIA will be prepared with the participation of the concerned municipalities, authorities etc. (the EIA process).

Before and during the work of site selection, permit application, facility design and final construction, consultation will take place with those most immediately affected, i.e. nearby residents, landowners, reindeer herders and representatives of whatever other interests there may be on the site in question.

8.2 SITUATION IN MUNICIPALITY

Comprehensive plan

Municipal planning efforts have mainly been concentrated on the mountain district – the Tärna section – in the west. The need for trade-offs between competing demands from different land-use and conservation interests has been greater here than in the eastern forested part of the municipality – the Stensele section. The "Comprehensive plan for Storuman Municipality" /8-3/ has the following to say regarding the Stensele section: "The area comprises a rural district situated in the forestland below the mountain region. An important objective of the plan work within the Stensele section of the municipality is to create the prerequisites for a living countryside. Different combinations of residence, agriculture, forestry, small-scale industry, tourism and work in the urban centre are the prerequisites for a positive development of this part of the municipality. The area is large and sparsely populated. Competition for land and water is small, as is land development pressure." A description of the municipality's societal premises is provided in the report /8-4/.

From the planning viewpoint, the siting prospects in the Stensele section are relatively good generally speaking, in terms of such factors as:

- large areas with interesting bedrock;
- relative nearness to infrastructure and communications;
- few competing land-use and conservation interests.

Agriculture and forestry

Agricultural land constitutes only a small portion of the surface area of the municipality, and it is steadily diminishing. Out of consideration for the long-term survival of agriculture, however, the comprehensive plan stresses the importance of keeping the best arable soils in the municipality in production. These are situated for the most part in the southeastern part of the municipality. However, considering the reduction of agricultural that is currently taking place, the municipality does not believe that it can be asserted in all situations that cropland should be exempted from development or other new use /8-3/.

The southeastern part of the municipality consists for the most part of forestland and belongs, with the exception of the areas at Gunnarn/Åskilje, to what is designated "difficult-to-regenerate forest". Conflicts of interest exist with, among others, reindeer herding, nature conservation, outdoor recreation and preservation of cultural monuments. The municipality says in the comprehensive plan /8-3/ that it is important that the restrictions that apply to forestry today will not be increased.

Reindeer herding

Reindeer husbandry can be pursued on both public and private land. The rights of the Sami people (Laps) are referred to collectively as reindeer husbandry rights in the Reindeer Husbandry Act and include the right to use land and water to sustain themselves and their reindeer.

There are two Sami villages in Storuman Municipality: Umbyn and Vapsten. In the near future, large areas within the municipality will be classified as being of national interest for reindeer herding. It is mainly a question of migration routes, night camps and gathering places, difficult passages, special grazing areas and calving areas. The areas and routes proposed by the county administrative board to be classified as being of national interest for reindeer herding are shown in Figure 8-1.

According to the Natural Resources Act, areas of national interest shall be protected wherever possible against measures that may substantially impede the conduct of reindeer herding. In the comprehensive plan the municipality stipulates that: "Reindeer herding is an important activity in Storuman Municipality, which must be assured of space and development possibilities". The activity is special in that it requires large areas and is conducted within different regions during different seasons and years.

Protected land with high natural merit

There are large areas within the southeastern part of the municipality that have high natural merit. As is shown in Figure 8-2, many of these areas are under some form of protection. Such forms of protection are:

- national interest for nature conservation;
- nature reserve;
- forest company reserves (Crown or MoDo reserves – not legally protected).

In addition to the areas that enjoy some type of formal protection there are a large number that have been designated by the municipality or the county administrative board as being interesting or valuable. There are other areas with old-growth forest worth protecting, rare lichens and habitats with endangered or rare animal species.

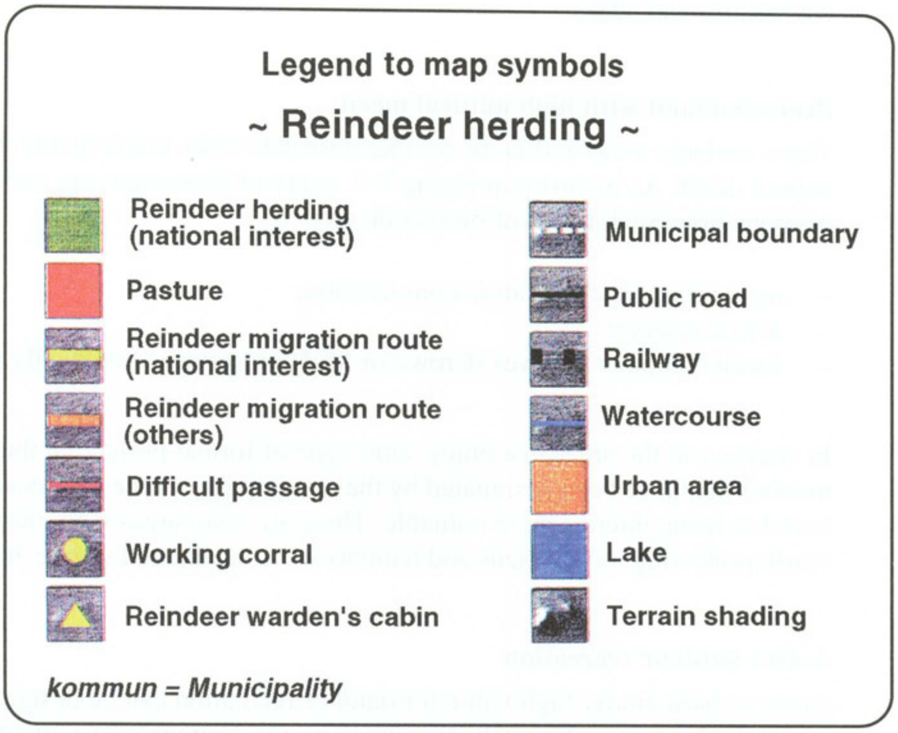
Active outdoor recreation

Areas of particularly high value for outdoor recreation can be designated as being of national interest. No such area involves the southeastern part of the municipality. However, many of the areas that are classified as being of national interest for nature conservation or interest areas for the natural environment are also of great value for outdoor recreation. In the trial planning "Land-use interests, guidelines for consultation" /8-5/, 40 areas or sites are designated as being of special value for local outdoor recreation. Only a few of these are situated in the eastern part of the municipality.

Outdoor recreation encompasses a variety of different leisure activities. The most important in Storuman are hunting, fishing, hiking, skiing, camping, canoeing, white-water rafting, snowmobiling and berry-picking.

The above activities are practiced within the municipality by both local inhabitants and visitors. According to the report "Tourism and nuclear waste in Storuman Municipality" /8-6/, it is a general trend that tourism with a focus on nature and culture experiences is increasing. Approximately 50% of those who visited Storuman during 1990-1992 stated that the purpose of their visit was nature-dependent. The municipality's mountain districts attract most of the tourists who are interested in active outdoor recreation.

Hunting is a form of outdoor recreation that engages a large portion of the population of Storuman Municipality. It is estimated that up to 80-90% of the adult male


Legend to map symbols
~ Reindeer herding ~
Reindeer herding (national interest)
Pasture
Reindeer migration route (national interest)
Reindeer migration route (others)
Difficult passage
Working corral
Reindeer warden's cabin
Municipal boundary
Public road
Railway
Watercourse
Urban area
Lake
Terrain shading
kommun = Municipality

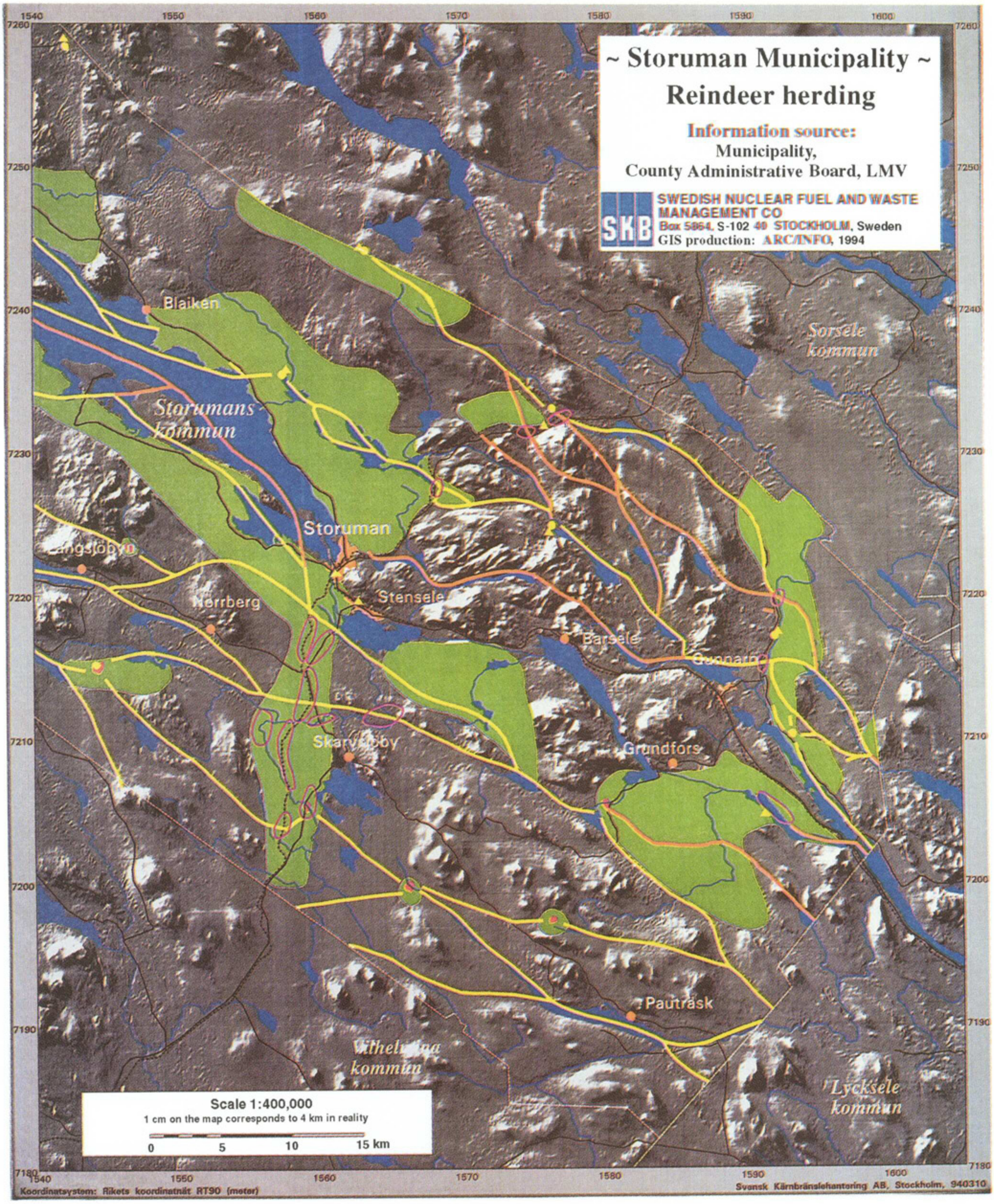


Figure 8-1. *Areas proposed as being of national interest for reindeer herding.*

(Source: The reindeer herding unit at the County Administrative Board in Västerbotten.)

Legend to map symbols

~ Protected nature areas ~

- Nature conservation area of national interest
- Crown and MoDo reserve
- Wetland site class 1
- Wetland site class 2
- Nature reserve
- Municipal boundary
- Public road
- Railway
- Watercourse
- Urban area
- Lake
- Terrain shading

kommun = Municipality

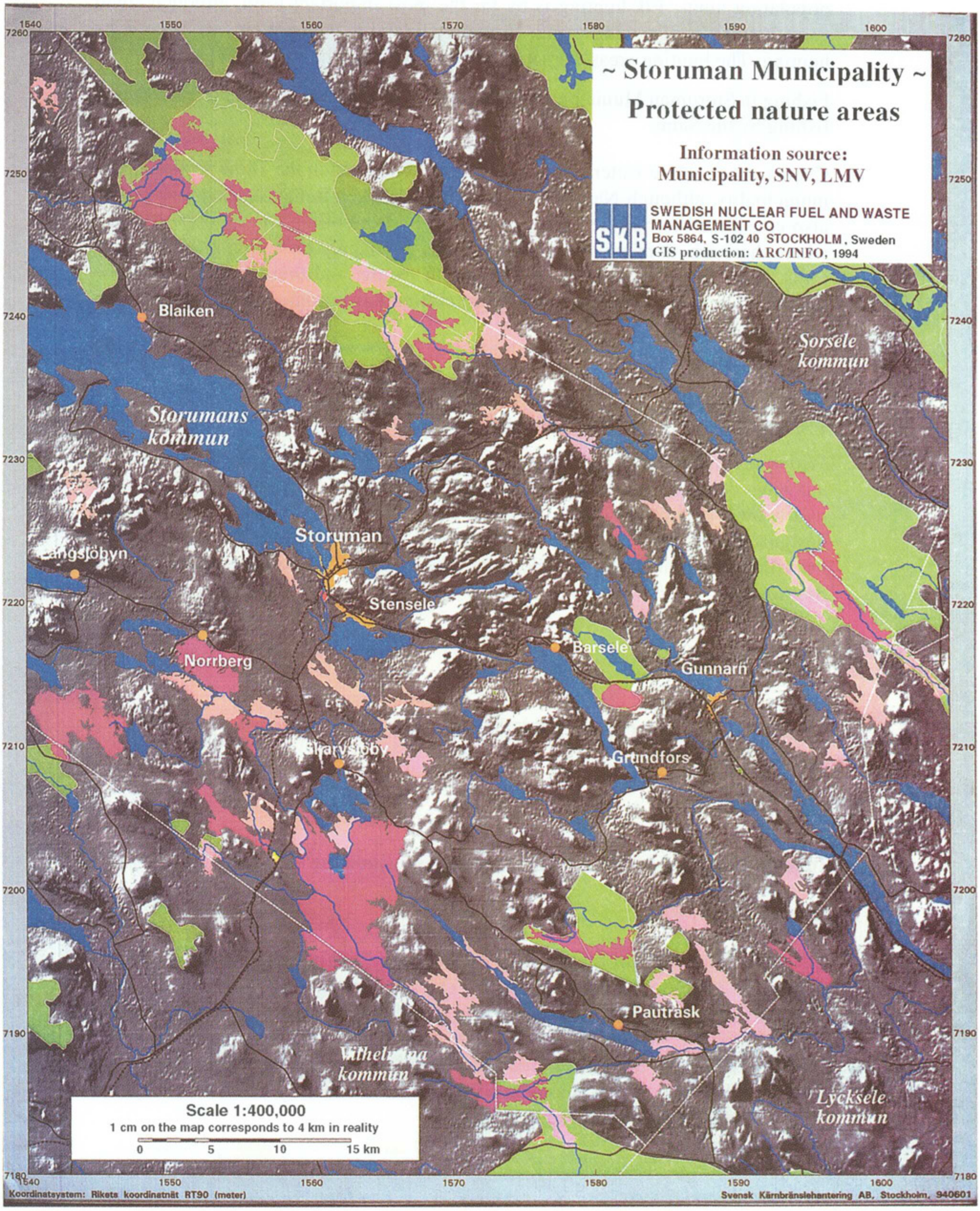


Figure 8-2. Protected nature areas.

population hunts. Elk hunting is by far the most important form, although small game hunting is also widespread. Virtually all land in the municipality is used for hunting. The hunting areas vary in size from about 500 ha to 20,000 ha.

Fishing in Storuman Municipality includes sport fishing (angling) and professional fishing by the Sami.

Canoeing and white-water rafting are mainly conducted in the Tärna section of the municipality, although Namonsbäcken and Storbäcken in the Stensele section are also considered to be fine canoeing waters. Snowmobiling can be done in areas where there are no restrictions. Snowmobiles are mainly driven on marked public trails. Most snowmobiling is recreational in nature, and there are several snowmobile clubs in the municipality. Snowmobiling has become a popular and widespread phenomenon.

Preservation of cultural monuments

Within the municipality of Storuman there are ancient remains, ruins of buildings and other cultural monuments. Many have been lost, however, mainly as a result of hydropower dam construction. There are two cultural environments that have been designated as being of national interest in the southeastern part of the municipality: the village of Gunnarn, Juktå colony and the Railway Environment in the town of Storuman.

8.3 ENVIRONMENTAL EFFECTS OF THE DEEP REPOSITORY

Impact on land use, natural and cultural environment

Area requirements

The surface facilities of the repository will occupy a certain land area, as will the road and railway to the deep repository. The land area will be occupied when the detailed characterization work gets started. The total area requirements of the surface facilities amount to about 18 hectares (600 x 300 m), while about 15 hectares (500 x 300 m) are required for rock waste dumps if the rock waste are not used for other purposes. It is assumed that the surface facility will have two paved access roads and possibly a rail connection.

Agriculture and forestry

In view of the location of the agricultural land and the limited extent of the surface facilities, it is scarcely likely that it will be necessary to make use of agricultural land for the establishment of a deep repository.

Forestry cannot be pursued on the land area occupied by the surface facility, road or railway. No negative impact on forestry beyond this can be foreseen. The activities pursued at the deep repository do not give rise to emissions of substances that could damage the forest.

Reindeer herding

If a deep repository is sited in Storuman Municipality, efforts will be made to avoid areas of national interest for reindeer herding as far as is possible and to avoid impairing reindeer husbandry in any other way. Similar consideration will be shown in the choice of route for and detailed planning of the road and railway lines.

For reindeer herding, a new rail connection will probably be as significant an intrusion as the actual surface facility.

The areas of national interest for reindeer herding that can be affected are night camps and gathering places, important grazing areas and migration routes, see Figure 8-1. Siting of surface facilities within these areas can affect migration and gathering of herds. It may, however, be possible within certain areas of national interest to site the surface facility without its impact being unacceptably great. In the event the facility is sited outside areas of national interest for reindeer herding, the impact can be limited to loss of grazing land and possibly impact during reindeer migration. The surface facility is not expected to disturb the reindeer appreciably other than in their immediate vicinity. The direct impact on reindeer that gather in the vicinity is therefore expected to be very limited.

The southeastern third of the municipality is located for the most part in the pre-winter and post-winter part of the reindeer herding land. This means that the reindeer are not present in the part of the municipality that is of interest for a deep repository during the sensitive calving season, which comes during the late spring.

In the event of a continuation of the siting studies in Storuman, it is important that thorough surveys be conducted of the impact on reindeer herding on the siting of a deep repository in a specific area. The surveys will require recurrent consultation and contacts with the Sami, the county administrative board and the municipality.

Natural environment

Siting within an area with protected nature or an area of interest for nature conservation entails a risk of conflict with the values or interests to be protected. In those cases where the value of the areas lies in the fact that they are relatively large and unaffected by human activities, a surface facility entails a conflict of interest.

How a surface facility affects the landscape will be highly dependent on the local premises and how the facility is adapted to the landscape. There is considerable flexibility to permit adaptation of the design of the parts of the facility to the local requirements.

Active outdoor recreation

Some conflict with hunting interests appears to be unavoidable if the deep repository is sited in Storuman. One or more hunting teams will be affected by the surface portion of the deep repository and the road and/or railway leading to it. The hunting team on whose hunting territory the deep repository is sited may, if the territory is very small, suffer a great loss of hunting land. If the facility is sited in a normal-sized hunting territory, the loss of hunting land will be small.

As far as fishing is concerned, the impact of a deep repository is judged to be very small provided that the most attractive fishing waters are avoided in the detailed siting of the facility and that appropriate consideration is given to the bodies of water that are of particular importance for fish stocks and other fauna and flora.

Conflicts with recreation in the form of hiking (walking), skiing, canoeing, etc. should be able to be avoided for the most part if the deep repository is sited in one of the four geologically interesting areas (Figure 5-6), with the exception of the Olbon area on the southern slope of Blaikfjället. There is scarcely a risk for any negative impact on berry-picking opportunities.

A new road and railway could cause "barrier effects". The small width of the road or railway line, the fact that fencing is not necessary and the limited traffic help mitigate these effects. However, a road or a railway line could constitute an emotional barrier in certain natural areas.

Cultural environment

The cultural environments worth protecting are not located in any of the geoscientifically interesting areas, and are furthermore all located so close to human settlements that they will probably not be affected by the deep repository. Other known ancient remains and cultural monuments are of such limited geographic extent that they should be able to be avoided when siting the deep repository's facilities.

Air pollution, noise and vibrations, etc.

Activities at the deep repository and transport to and from it will inevitably cause some environmental impact due to vehicle exhaust emissions and emissions of blasting gases. This also applies to other disturbances such as noise, vibrations, lights, etc. These types of environmental impact will mainly occur during the construction phase. Environmental impact during the operating phase will probably be less in many respects. Calculations for all the above-mentioned disturbances show that the environmental impact can be regarded as moderate or slight /8-1/.

Accidents, fire, etc.

The activities at the surface facility must be regarded as uncomplicated in comparison with other industrial activities. It is difficult to pinpoint any possible accidents with environmental impact. Explosions caused by blasting explosives or LPG and fires in tanker trucks or fuel depots are probably the worst possible accidents in this respect. The environmental consequences of such accidents are limited to smoke emissions and spillage of oil, fuel or other chemicals.

Impact on the water

Lowering of groundwater table

The groundwater table will be drawn down locally in conjunction with tunnelling during detailed characterization and operation. The amount of drawdown will depend on the occurrence of water-bearing fractures and fracture systems, and the scope of grouting measures adopted. Experience from mines and from the Äspö HRL suggests that the quantity of groundwater that has to be pumped up from a fully excavated facility may amount to a cubic metre or so per minute. The drawdown may affect wells within a few kilometres of the deep repository. A minor and temporary drawdown may also occur during test pumpings of boreholes in connection with the site investigations.

Water supply

The water supply for the facility will be arranged locally. The total requirement can be estimated at about 100 m^3/day. Since the underground work will probably cause a rather large groundwater lowering and there are probably not any suitable eskers in the vicinity, water will probably be taken from some not-too-distant lake or watercourse.

Water pollution

No real industrial process takes place at the facility, which means there will be no process discharges.

The water pumped up from the facility must nevertheless be checked for contaminants such as oil, rock dust and nitrate from explosives. If it is contaminated, the water must be purified before it is discharged. In those phases when large quantities of water are pumped up, the water will pass through settling ponds and oil separators prior to discharge to a receiving body of water or soil infiltration.

The deep repository will not give rise to any wastewater of a more troublesome nature than, for example, a manufacturing company. It is assumed that the wastewater will be treated before being discharged to a receiving body.

Leaching of rock waste dumps

The rock waste that are hauled up may be dumped near the surface facility. They will consist of granite without any appreciable content of harmful contaminants. If such contaminants should nonetheless occur in significant concentrations, leaching of these substances to the groundwater must be limited, for example by a suitable thickness or composition of the soil layer used to cover the spoils.

Radon from rock waste dumps

Calculation of radon emission from the rock waste dumps shows that any additional emission is small when compared with the natural radon emission from surrounding terrain /8-7/. The radon concentration in the air at a height of 1-2 metres above the rock waste dumps is estimated at 2-10 Bq/m^3, which is much lower than the limit (200 Bq/m^3) that applies to newly built premises in which human beings are commonly present.

Possible impact on flora and fauna

The activities at the deep repository are of such a nature that the local animal and plant life will not be affected except for on the land that is directly occupied by the facility and in the immediate environs. The animals assumed to be most sensitive to noise, light etc. are large mammalian predators and birds of prey, which will probably move away from the neighbourhood if they are disturbed.

The risk of barrier effects, i.e. restriction of mobility in certain directions for animal life and outdoor recreation activities, is judged to be small. This is because of the relatively limited area occupied by the surface facility, the connecting roads and railway, and the low traffic intensity on them.

Air pollution caused by the deep repository is not judged to have any impact on the vegetation.

Management of natural resources

The deep repository does not require utilization of any natural resources of which there is a regional or global scarcity.

Siting of a deep repository in the municipality of Storuman could, on the other hand, affect the management of the natural resources that exist within the municipality by blocking access to them. Such natural resources are primarily the natural environment, mineral resources, groundwater and peat. As mentioned previously, consideration will be given to these natural resources in conjunction with siting, so no appreciable impact on their management is expected.

Site restoration

After the repository has been closed and sealed, the groundwater table will eventually resume its former, natural level. This can be expected to take several decades. During this period the site will be restored to a condition that is as close to the original condition as possible.

The buildings at the deep repository can be regarded as conventional industrial buildings. When and if they are demolished, the demolition waste will not differ significantly from other industrial building waste. Early planning in accordance with the ecocycle principle (reuse, recycling and recovery) will facilitate the reuse of building materials.

As mentioned previously, the hauled-up rock waste dumps will be covered with soil. Since the rock waste consist of granite, they do not present the same problems as mining wastes, although they do have to be disposed of in such a manner that they blend in with the landscape. Nevertheless, the dumping areas must be regarded as permanently affected, which means that it will not possible to return to the same habitat as existed there before.

No restrictions need be imposed on land use on the restored site, with the exception of a ban on deep drilling. The site should be permanently marked in some fashion. Records of the existence and contents of the repository will be filed in such a manner that they are not destroyed.

8.4 VERY LONG-TERM ENVIRONMENTAL IMPACT

The design of the deep repository and all measures in connection with deposition aim at containing and isolating all radioactive materials. A central portion of the environmental impact assessment for the deep repository is the assessment of the very long-term radiological safety.

Encapsulated spent nuclear fuel

When the spent nuclear fuel is emplaced in the deep repository, it will be encapsulated in durable canisters. The canister is one of the most important barriers in the deep repository, since it is expected to keep the fuel isolated from the groundwater over a very long period of time. The canister also facilitates handling of the fuel in conjunction with deposition in the deep repository.

The most important requirement on the canister is that it shall remain intact over a very long period of time in the environment which will prevail in the deep repository. Thus, it must not corrode ("rust") in the groundwater that is present in the rock or be fractured by the mechanical stresses to which it is subjected in the deep repository.

To achieve this, the canister is planned to be made with an inner container of steel, which provides mechanical strength, and an outer canister of copper, which provides corrosion protection. Copper corrodes very slowly in the oxygen-free groundwater present at depth in the Swedish bedrock. Completed studies show that the canister will probably remain intact for millions of years, i.e. much longer than the 100,000 years during which the spent fuel is more dangerous than a rich uranium ore.

Encapsulation is planned to take place in a new plant connected with CLAB in Oskarshamn Municipality. In the encapsulation plant, fuel will be received from CLAB's storage pools and placed in a canister after being checked and dried. Before the lid is placed on the inner steel container, the void in the canister may be filled with e.g. glass beads and inert gas. Following this, the lid will be welded on the canister using electron beam welding techniques. The weld must be free of leaks and satisfactorily undergo control testing. After inspection to make sure the canisters are leaktight and clean, they will be taken to the deep repository.

Other waste

Other waste that is planned to be deposited in the deep repository is comparable to that which is deposited today in SFR (final repository for radioactive operational waste) in Forsmark. It consists of discarded filter resins, metal scrap and other material that has become radioactive during operation of nuclear energy plants. Some consists of radioactive waste from research, medicine and industry. The waste is immobilized and packed in containers of steel or concrete. The difference compared with the waste deposited in SFR is that some of the waste to be sent to the deep repository will contain more long-lived radionuclides. The differences are not great but enough to warrant deposition at a greater depth than at SFR, which is 50 m down in the rock.

The deep repository will also be able to receive waste after SFR has been closed. The total volume of other waste is estimated to amount to 20,000 m^3.

Safety assessments

Several safety assessments will be conducted for the deep repository, due to the step-by-step nature of the decision process. The first site-specific safety assessment will be done in connection with application for a permit to conduct detailed characterization of a proposed site.

The second will accompany SKB's application for a permit to build the repository on the investigated site. Later, additional assessments will be required before SKB is allowed to start waste deposition and before the repository can be closed. At each step the assessments are based on increased knowledge and a larger body of site-related data.

Each safety assessment will be scrutinized thoroughly by several authorities and agencies, both inside and outside Sweden, before a final decision is made. In this way the public is guaranteed that the safety assessment on which a decision is based takes into account up-to-date knowledge and proven science and technology.

In connection with the research conducted by SKB, and in conjunction with various permit applications, radiological long-term safety has been analyzed and described in various reports /8-8/, /8-9/. Similar studies have also been conducted by Swedish government authorities /8-10/ and in other countries, including Finland /8-11/.

The results of these studies show that it is possible, by means of design measures and a careful choice of site, to surround the radioactive waste with both engineered and natural barriers that prevent the escape of radionuclides. Calculations show that under these conditions it is possible, with good margin, to prevent radionuclides from being released in quantities that exceed established limit values.

The investigations that have been made of the bedrock in Sweden during the past 18 years show that the properties that are necessary for a safe repository (see Chapter 3) may exist on many sites. This is true even under the special conditions that prevail during an ice age.

As already mentioned, it is not possible to perform a site-specific safety assessment of a deep repository in Storuman in the feasibility study. Such an assessment requires information on such properties of the bedrock as fracture characteristics, hydraulic conductivity, groundwater chemistry etc. – information that can only be obtained after extensive borehole investigations.

8.5 DAMAGE PREVENTION

The impact of the deep repository can be minimized by means of damage prevention measures both during siting and during the later phases. Such damage prevention measures may include:

- inventory of flora and fauna with a focus on sensitive habitats and areas that may be of importance for biological diversity. Possible conflicts with nature interests, even on a small scale, should be recorded, such as populations of plants worth protecting, breeding sites for birds of prey, etc.;
- mapping of surface water and groundwater conditions, regional flow paths, sensitive wetlands and habitats;
- inventory of domains where impact on the landscape should be minimized;
- inventory of present-day and possible future outdoor recreation activities in the area;
- inventory of natural resources that may be eventually impeded by the facility;
- landscape adaptation and detailed layout of the surface facility;
- learning from experience gained from environmentally sound (ecological) construction, e.g. regarding choice of materials, recycling potential, energy and water supply;
- use of environmentally friendly fuels;
- early planning of chemical handling, alternatives to polluting methods and products;
- monitoring programme for e.g. discharges, emissions and noise, and environmental monitoring;
- special measures and consideration during the construction phase and operating phase.

8.6 LAND USE AND ENVIRONMENTAL CONDITIONS IN GEOLOGICALLY INTERESTING AREAS

Four areas are presented as being of interest for further studies in Chapter 5, Geoscientific premises (Figure 5-6). A brief assessment of the prospects of these areas with respect to land use and environmental conditions is given below.

The Norrberg area is virtually undeveloped with the exception of the village of Norrberg. There is a large telecommunications mast and a few logging roads on Sabotsliden, while the southern parts down towards Inre Verkanliden have almost no roads or buildings.

Luspberget, in the northern part of the area, has unlogged areas with lichens and other plants that are worth protecting. Areas of national interest for reindeer herding are located in the northern and southwestern parts of the area. Two wetlands belonging to protection classes 1 and 2 are situated in the central part, separated by Namonsbäcken creek. Fishing and camping occur around the creek. With the exception of these areas, which are worth protecting, there are good prospects for avoiding or limiting conflicts with existing land use and natural merits.

The Olbon area is free of buildings, roads and other development. The area is situated for the most part within a nature protection area. Immediately south of the nature protection area, but inside the geologically interesting area, is Olbonhobbarna with virgin forest and interesting bird habitats. The outskirts of the area border on areas of national interest for reindeer herding.

The Olbon area is a popular area for leisure activities and outdoor recreation. The area has beautiful and interesting natural features. Siting of a deep repository in this area would make conflicts with active outdoor recreation difficult to avoid.

The Joran area is sparsely developed. There are no records of areas that are of great natural beauty or of any particular interest for outdoor activities, with the exception of Joranbäcken creek. Bird inventories have not yielded any interesting results.

There would appear to be little risk of conflicts with active outdoor recreation within the Joran area, with the exception of some impact on hunting. Consideration must, however, be given to sport fishing in Joranbäcken creek. There are areas of national interest for reindeer herding within a few smaller parts of the Joran area. Among other things, there is a migration route along Joranbäcken creek.

The size of the Joran area, in combination with the sparsity of settlements and the relatively few competing land-use and preservation interests, should provide ample opportunities for detailed siting so that the impact on land use and the environment is limited.

The Lumsen area is undeveloped – with the exception of a few houses, mainly weekend cottages – but borders in the southwest on built-up areas and the agricultural and cultural environments of national interest at Juktån and Gunnarn.

The area runs alongside of, but lies in its entirety southwest of, the nature protection area at Lycksamyran mire. On the east, however, the area borders on a couple of wetlands in protection class 1 and 2. Aside from hunting, there is little outdoor recreation activity in the area. The risk of conflicts of interest with active outdoor recreation is judged to be little. On the southwest the area borders on an area of national interest for reindeer herding with migration routes.

8.7 PROSPECTS WITH RESPECT TO LAND AND THE ENVIRONMENT

Criteria/factors

Site selection and design of the facilities shall be done so that conflicts with competing land-use interests are minimized. Consideration shall thereby be given to nature, the environment, cultural monuments, recreation, hunting, fishing, other outdoor activities, important natural resources, agriculture and forestry, and other current and planned land use. Facilities and transport routes shall blend in smoothly with the terrain.

To comply with the requirements laid down in the environmental legislation, the facility's environmental impact must be weighed against the specific environmental conditions in the area already during the siting process. In short, the site for the deep repository shall have few competing interests for land use and shall offer good prospects for being able to build and operate the facilities in compliance with all environmental protection requirements.

Storuman Municipality

Generally speaking there are good prospects for being able to minimize conflicts with competing interests within the vast eastern part (the crystalline rock part) of the municipality. With the exception of the valley of the Ume River, the most important stakeholders in this part of the municipality are landowners, timber interests and reindeer herders.

A deep repository causes little environmental impact compared with ordinary industrial plants of similar size. This, in combination with the small area requirements, means that the impact on flora and fauna, air, surface water, groundwater and agriculture will be slight. The impact on outdoor recreation, hunting and fishing will probably be limited to the areas situated immediately adjacent to the facility and any new connecting roads and railway. As far as reindeer herding interests are concerned, it is primarily important to limit intrusion into areas of national interest, but siting in other areas might also have an impact on reindeer herding.

An evaluation of the suitability of the four geologically interesting areas with respect to land use and the environment shows that it has not been possible to identify any absolute obstacle to a siting in this phase. The Olbon area appears to be the area in which the risk of conflicts with competing interests is greatest. The area in which a siting would entail the least disturbance is deemed to be the Joran area.

In the event further studies are undertaken in any of the areas, consultation should be established with landowners, residents, reindeer herders and others with interests in the area in question.

9 WORKING ENVIRONMENT AND RADIATION PROTECTION

This chapter briefly describes the working environment in a deep repository and the radiation protection measures that will be adopted.

9.1 INTRODUCTION

All types of jobs that will exist in the deep repository and along the transport route from the encapsulation plant and the coastal harbour already exist today in various industrial contexts. Construction and operation of underground facilities, as well as heavy transport, are activities with a long tradition in the county. The activity which Storuman Municipality lacks experience of is handling of radioactive packages on the scope entailed by the deep repository.

Among the working environments encountered in a deep repository, underground activities are probably the ones that get the most attention. In the initial construction phase, the working environment can be compared to that in a mine. Even when deposition of canisters is under way, rock work will still continue as the underground portion of the facility is steadily expanded. The areas in which excavation operations are under way will be separated from those sections where deposition has commenced or being prepared, and these different activities will not affect each other. The parts of the facility where rock excavation work is not under way are comparable to power stations or underground military facilities.

The description of the working environment provided in this chapter is based on the planned design of the deep repository and is relatively independent of where the facility will be sited. Here, as elsewhere in the report, the emphasis is placed on handling of canisters with spent nuclear fuel, while other waste (concrete moulds with immobilized core components, etc.) is dealt with more briefly. This is because the work in conjunction with deposition of the latter waste is simpler. It is comparable to that being done today in SFR. The part of the repository where other waste is deposited will be separate from the area where canisters are deposited.

9.2 RADIOLOGICAL WORKING ENVIRONMENT

Monitoring of the radiological working environment during transportation and handling at the deep repository will conform to the customary standard for nuclear activities. The fundamental principle in all work with radioactive materials is that the total exposure to the personnel (dose) shall be the minimum necessary for execution of the work. A more detailed description of radiation and the radiological aspects of work in the deep repository is provided in /9-1/.

Transport from encapsulation to deep repository

The canisters with spent fuel are contained during transport in transport casks with steel walls up to two decimetres thick (see Chapter 7). The primary purpose of the transport casks is to shield off the radiation from the canisters so that the casks can be handled without danger to the transport personnel. The casks also provide mechanical protection that prevents the canisters from being damaged during transport.

The casks shall comply with international rules regarding, among other things, strength and maximum radiation level.

During transport the radiation level from the casks will always lie under relevant limit values, which means that the only protective measures taken for the personnel are to limit the time spent next to the containers to what is needed to carry out loading and unloading. This is in keeping with the principle that all unnecessary radiation shall be avoided. Experience from today's sea shipments of casks containing spent (but not encapsulated) fuel assemblies to CLAB shows that the system can be designed in such a way that the actual radiation dose to the personnel is well below relevant limit values. As an example it can be mentioned that the crew of the ship M/S Sigyn has received lower radiation doses than the average Swede receives due to natural background radiation. This is because radiation levels are generally lower at sea than on land and the radiation from the casks does not significantly influence the low background level.

Reception at the deep repository

Between the time the railway cars with transport casks arrive at the deep repository and the time when the casks are transported down to repository level to be emptied of their contents, the only handling to which they will be subjected is unloading, marshalling and possibly temporary storage. This handling, which takes place within the deep repository site, is thus comparable to that performed by the transport personnel.

Down-transport and deposition

Handling in the deep repository can also be designed so that personnel doses are kept way below relevant limit values. Different parts of the facility will be divided into zones according to radiation level. Dosimetry will be used to monitor radioactivity. No airborne activity (except radon from the rock) or surface contamination will be present, which means that no special clothing is needed.

Down-transport will take place either by means of vehicles in the tunnel or by means of a hoist (mine hoist) down to the deposition level. In the meantime, the canisters will be contained inside their transport casks. (The same applies if other waste is handled.)

At the mouth of the deposition tunnel, a deposition machine will open the transport casks and take the canister for further conveyance to its deposition hole. A few persons will be occupied with this work.

Of those who work at the deep repository, this is the only personnel category that can be expected to receive measurable dose contributions from the waste being deposited. Extensive steps will be taken to minimize the radiation doses to the personnel. The equipment will be remote-controlled and equipped with radiation shields, thus preventing the personnel from coming into direct contact with the canisters.

The dose contribution must naturally lie below the limit values set by SSI for persons who work with ionizing radiation. In practice it can be assumed that the doses will be much lower than the maximum values calculated in the design phase. For example, experience from SFR in Forsmark shows that the radiation doses are ten times lower than those calculated when the repository was commissioned /9-1/.

A stipulation with work associated with ionizing radiation is to keep all radiation doses as low as is practically possible (even when they are already well below relevant limit values). When designing the facility and the equipment and machines that will be employed there, this goal will be of great importance. To give the personnel the knowledge and skills they need to contribute towards this goal, they will be given suitable training, both on the subject of radiation and in the handling of canisters and equipment. Experience from e.g. SFR and CLAB can be valuable here. Personnel categories that do not work directly with deposition shall also be given basic training, since a general understanding of the applied requirements and principles of safety and radiation protection contributes both to increasing job satisfaction and to reducing the risk that any measure will be taken which is in any way counterproductive to these purposes.

A contributing factor to keeping the radiation doses down is the fact that the equipment is designed for high reliability. Furthermore, detailed instructions on how the work is to be done will be provided and followed. In this way, unscheduled interruptions and time-consuming repairs can be avoided.

In the event of a breakdown of the handling and deposition equipment, either the equipment or the canister will be moved out of the way so that repairs can be made without exposing the personnel to radiation. Should this be impossible or impractical for any reason, temporary radiation shields will instead be erected so that repairs can be made without risk to the personnel.

9.3 RADON

General

Since the deep repository is a rock facility, there is another source of radiation, namely the radon gas that is released from the bedrock itself. Unlike the radiation from the waste, which only affects the personnel who work with handling and deposition, all personnel who work underground are exposed to radon.

It is above all when the radon concentration in seeping groundwater is high that special ventilation measures are needed /9-2/. Other radon sources, which however are of secondary importance, are radon emission from the rock walls and radon emission from crushed rock that is laid out as road metal on the tunnel floors.

Today the limit value for radon is 2,000 Bq/m^3 in underground facilities (workplace for 2,000 hours/year). In the future it is likely that this limit value will be set at 200 Bq/m^3 in the air, regardless of whether the workplace is above or under ground. Extensive engineering measures are required to achieve this in a uranium-rich bedrock.

Radon occurrence in existing rock facilities

Radon measurements are performed regularly in a number of rock facilities in Storuman Municipality. Such measurements in the Juktan hydropower station have indicated high levels, locally far above relevant limit values, which has occasioned measures during both the construction and the operating phase. During the construction phase, these measures caused considerable inconvenience /9-3/. The measures taken during the operating phase have included a closed piping system for collection of seeping groundwater and a "radon lock" with a special ventilation technique. All in all, the radon problems in the Juktan plant are described by those in charge of construction and operation as being considerably more manageable now, but at the price of considerable investments. Regular radon measurements are also being performed in other power stations and defence installations. The results indicate lower radon concentrations than relevant limit values, so no measures beyond customary ventilation have been adopted there.

The conclusion is that a deep repository situated in any of the large granites in Storuman may lie in a bedrock with a relatively high radon emission. If this is the case, measures must be taken to keep the radon level below the limit value. An example of such a measure is that seepage water, and radon that has degassed from seepage water, are collected near the source and conducted away in closed systems. Furthermore, extensive general ventilation of tunnels and rock caverns may be required, along with local ventilation at working faces. In extreme cases the engineering solutions can be complicated and therefore expensive to implement.

9.4 WORKING ENVIRONMENT IN OTHER SERVICE AREAS

Traditional working environments for offices, workshops and construction above and under ground will exist at the deep repository. Examples of work duties are geotechnical and similar investigation and analysis work, administrative work and routine handling of large vehicles and heavy goods, including maintenance and repairs (see Chapter 6).

Great care will be devoted to designing the surface buildings so that they blend in as unobtrusively as possible with the environment and so that pleasant workplaces are created. The goal in the office and the workshops on the surface is to create an internal environment that balances function and technical requirements with uniform design solutions and good accessibility for service and maintenance.

9.5 PROSPECTS WITH RESPECT TO THE WORKING ENVIRONMENT

Criteria/factors

There must be good opportunities to build and carry out all activities in the deep repository in a safe manner.

General

Radiation from the waste to the deposition personnel will be minimized with the aid of remote-controlled equipment and radiation shields. The extra radiation dose to which the deposition personnel will be exposed will therefore be very low (experience shows that it will be far below the maximum permissible limit value). Other personnel will not be exposed to any measurable radiation from the waste.

The working environment for other jobs can be compared with that for traditional duties at engineering companies and offices.

A deep repository must be designed to conform to high working environment standards. Nonetheless, experience shows that underground rock construction poses risks of occupational injuries. Handling of rock waste and transport of other heavy materials also entail accident risks. The facility will be designed to minimize these risks.

Storuman Municipality

A special feature of Storuman is the presence of granites with unusually high uranium concentrations that can give rise to high radon levels. From an occupational safety point of view, the radon concentration must be kept low, which may require special engineering solutions which, in combination with increased ventilation, may entail high operating costs.

10 SOCIOECONOMICS

Storuman Municipality and the prospects for the siting and establishment of a deep repository there are described from a socioeconomic, "non-technical" perspective. History, present-day situation and possible future development with respect to population, business and industry, labour market, tourism, services and municipal finances are dealt with. The purpose is to shed light on the probable socioeconomic consequences of the siting of a deep repository in Storuman Municipality.

The socioeconomic studies undertaken in the feasibility study deal with the future development of the municipality both with and without a deep repository. Future prediction of a society is always an uncertain business, and the values and predictions are those of the investigators. Most of this chapter therefore takes the form of summaries from the various studies.

10.1 STUDIES

The scope of the various studies was initially discussed with the municipality and with local representatives of political parties, companies, associations and other interest groups. The discussions were carried on via the project's steering and reference groups and led to the establishment of the principal guidelines in a special "Socioeconomic study programme" /10-1/. During the course of the work, the discussion has continued regarding the issues, the incoming results and the need for special supplementary work.

The socioeconomic studies was initially divided into four specially identified areas:

- **Socioeconomic consequences of a deep repository for spent nuclear fuel in Storuman Municipality** /10-2/ with Professor Einar Holm at the Department of Geography at Umeå University as the principal investigator. This study consisted of a main study of the socioeconomic consequences and three subsidiary studies dealing with psychosocial aspects, previous hydropower construction and interviews with local persons within various fields in the municipality. This chapter presents the results of the main study and the psychosocial study.
- **Business environmental assessment:** "Storuman on the eve of the new millennium – a business environmental perspective" /10-3/ conducted by Carl Fredriksson et al. at EuroFutures AB in Stockholm.
- **Impact on tourism** where Christina Olsson has conducted the study "Tourism and nuclear waste in Storuman Municipality" /10-4/ under the supervision of Professor Lars Hultkrantz at the Department of Economics at Umeå University.
- **References from major civil engineering projects** /10-5/. Lars Welander at Vattenfall Energisystem AB has in a special study compiled and analyzed experience from somewhat comparable projects in other parts of Sweden.

In conjunction with the presentation of the results from the four above-mentioned surveys, the need for supplementary surveys was identified regarding the effects of a deep repository on the local economy and tourism. This resulted in the following studies:

- **The future in Storuman/Stensele – Employers in focus** /10-6/. The study was conducted under the auspices of Storumans Utvecklings AB (SUAB) via Assistant Professor Owe R Hedström.
- **Development of tourism in Storuman and southern Lappland with or without a deep repository.** A study which describes how the tourist industry views the establishment of a deep repository in the form of interviews conducted by Turismutveckling AB in Östersund.
- **Future development of tourism – assessment criteria.** A forecast of the development of tourism globally, nationally and regionally (Norrland and Västerbotten) compiled by the Mitthögskolan in Östersund.

The two last-named tourism studies have been compiled together in a report entitled "Development of tourism" /10-7/.

The socioeconomic studies have primarily concentrated on prospects and consequences for Storuman Municipality, but some light has also been shed on regional aspects of interest. The description assumes today's conditions in the municipality and describes probable outcomes and consequences by comparing a reference scenario without a deep repository with a scenario with a deep repository. In this way a basis is obtained for a discussion of what the municipality's future may look like, whether or not a deep repository is actually established there.

The timescales that have been studied span nearly a century from the present to the end of the next century, which is warranted by the direct and indirect effects that could be discerned before, during and after the approximately 50-year period (2000–2050) spanned by the construction, operation and closure of a deep repository.

The results of the studies must be judged keeping in mind the uncertainties that always exist in forecasts of societal development extending over long periods of time.

10.2 STORUMAN TODAY

This section is based primarily on "Socioeconomic consequences of a deep repository for spent nuclear fuel in Storuman Municipality" /10-2/. The figures are taken from "Storuman on the eve of the new millennium – an business environmental perspective" /10-3/.

Population

Storuman is one of the largest municipalities in Sweden in terms of surface area, with its 7,500 km^2. The size of the population has fluctuated rather widely over the past few decades. At the end of the 1950s the population numbered about 11,000 inhabitants (Storuman's comprehensive plan /10-8/). By 1972 the figure had fallen sharply, but this downward trend slowed down somewhat during the '70s and '80s. At the start of 1994 the population of the municipality amounted to 7,602.

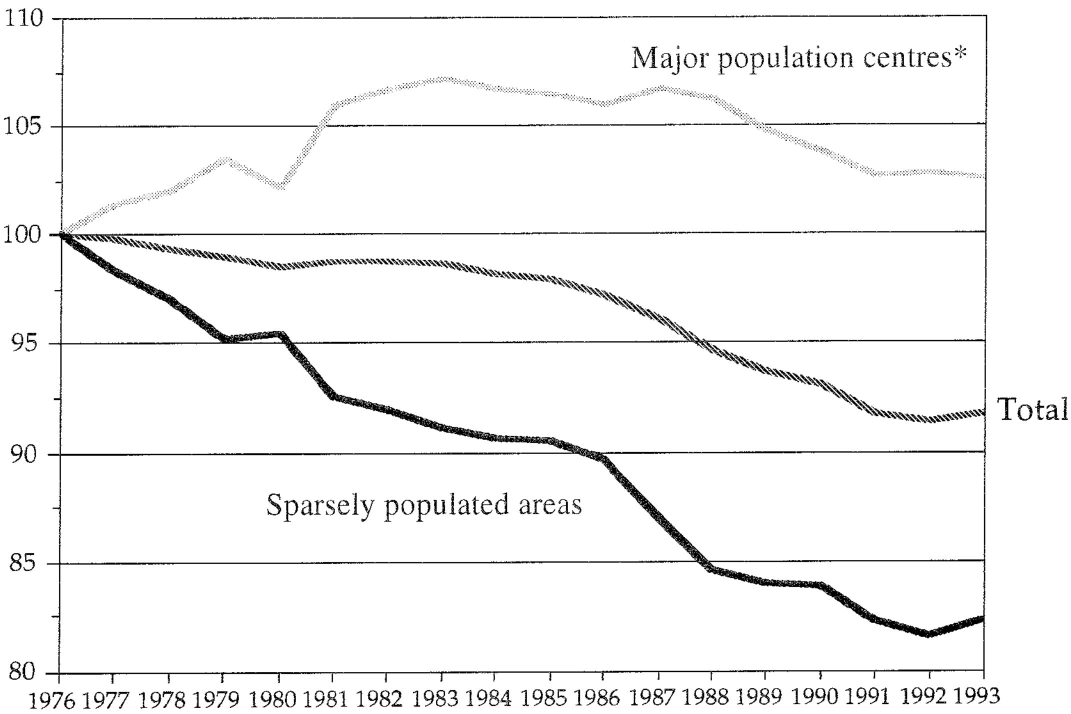


Figure 10-1. *Population curves (reported as index) in major population centres and in sparsely populated areas in Storuman Municipality. *Major population centres include Storuman/Stensele and Tärnaby/Hemavan.*

The population decline has not been equally great in all parts of the municipality. The communities, especially Tärnaby and Hemavan in the mountain district, have managed to retain a relatively constant population through the years, while the countryside and the southeastern part have lost population, see Figure 10-1. The trend in the northwestern parts is largely associated with the growth of the tourist industry, which has entailed new job opportunities for the female population as well. As the population has declined, the demographic mix has also changed. The population has become older due to a lower nativity rate and the fact that young people have moved away from the municipality, see Figure 10-2. The negative population trend is linked to a large extent to the situation on the labour market. In the long-term, a stagnant labour market increases the pressure on people to move.

Economy and labour market

Unemployment is high in many inland municipalities. During 1992, 10% of the working-age population was without work in Storuman. This figure would presumably have been higher if people had not moved out at the rate at which they have done so in recent years.

Previously, most jobs in the municipality were in agriculture and forestry, but these sectors have declined substantially in importance. The centre of gravity on the labour market has gradually shifted to public sector jobs, tourism and industry. The need for personnel within most industrial sectors is steadily declining due to rationalization and technical innovations. As in most municipalities, the employment level in traditional industry is difficult to uphold. New products and niches are needed for expansion. The tourist industry is assumed to have good development potential, while the future outlook for public services appears increasingly

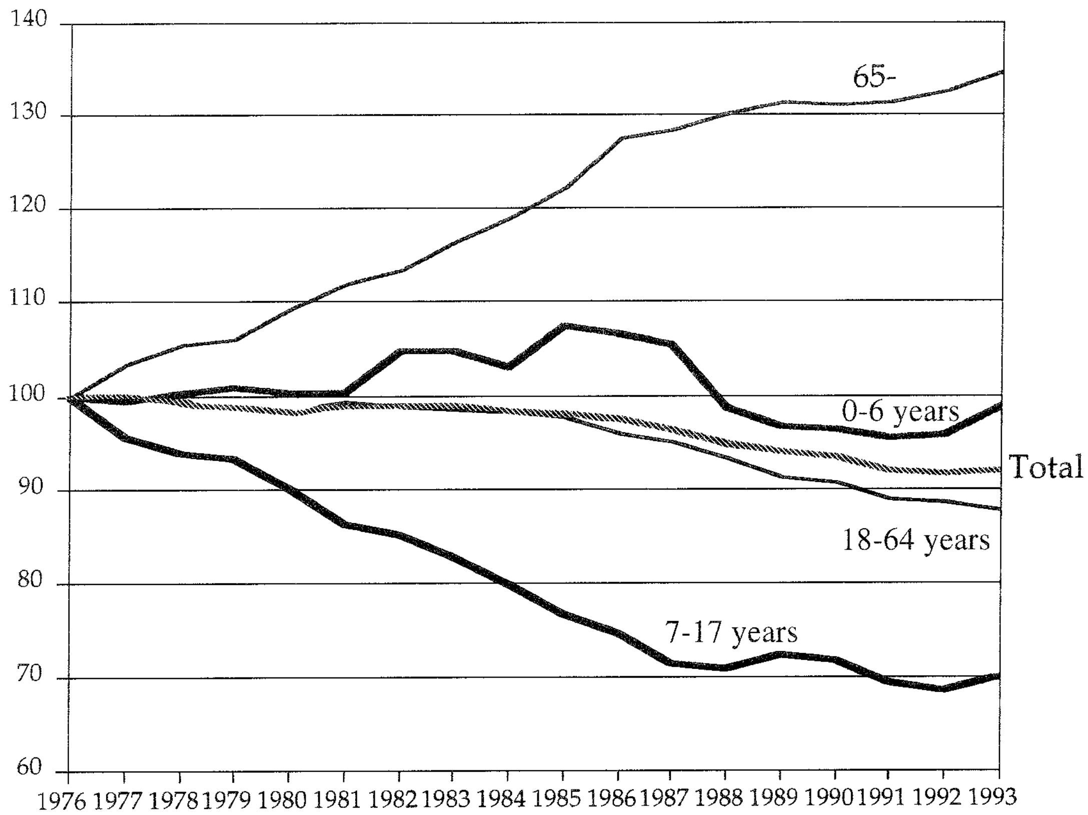


Figure 10-2. *Population curves (index) for different age groups in Storuman Municipality.*

uncertain (Industrial policy programme, Storuman Municipality /10-9/). Table 10-1 shows the number of persons employed in different economic sectors and how the number of jobs has varied since the beginning of the 1980s.

Table 10-1. Number of persons employed in Storuman Municipality in different economic sectors in 1980, 1985 and 1991.

Economic sector	1980	1985	1991
Agriculture and forestry	535	468	223
Manufacturing etc.	670	726	510
Construction	366	264	285
Commerce	319	267	273
Transport and communication	317	334	244
Private services	313	371	491
Public administration and services	953	1,087	1,168
Other	3	149	39
Total	**3,473**	**3,666**	**3,233**

Source: Nutek/Umdac 940204

Over the course of eleven years, the number of persons employed has decreased by 240 (viewed over the most recent six-year period the decline is 433 persons). All sectors except private and public services and public administration have declined. Some of the growing tourist industry is found within the group "Private services", which explains some of the increase. It is estimated that the tourist industry generates 200-300 annual jobs /10-4/ spread out over a large number of entrepreneurs.

The transfer payment system (transfer of tax revenues from state to municipality and between municipalities, in part via the tax equalization contribution) which has evolved over a long period of time has, aside from regional policy, created opportunities for people to live in places that have not been prioritized by the players on the private market. An analysis of the state's geographically-related resource transfers shows that labour market regions in Norrland dominate, together with Karlskrona/Ronneby in Blekinge. Storuman has an index value of 131, which means that the municipality receives 31% more state resources per person than average (NUTEK Report 1993:55).

The economic and political prospects for maintaining the present-day scope of regional resource levelling are uncertain. A progressive reduction of public-sector activities and individual transfer payments is reducing opportunities for finding employment and a livelihood in vulnerable inland municipalities.

Sweden is being forced by internal deficits, its dependence on world markets and international competition to reduce and streamline its public sector. Those municipalities that have a high proportion of public employees may be hard-hit by cutbacks. According to the estimates of the county administrative board, these cutbacks will particularly affect Umeå and the interior, which have a high proportion of their labour force in public-sector activities.

Table 10-2. Storuman's twelve largest employers 1993.

Employer	Number of employees
Storuman Municipality	650
Västerbotten County Council	120
Samhall SAFAC AB	120
Vattenfall AB	100
Byggelit AB	70
Storuman municipal housing	50
Swedish State Railways	40
Rottne-SMW AB	30
National Road Administration	30
Sweden Post	30
National Police Board	30
Forest-Owners Västerbotten	30
Total	**1,330**

Source: Nutek/Umdac 940110

Table 10-2 shows that most big employers in the municipality are organizations with a more or less close link to municipal, regional and national interests.

Future plans and education

The downward population trend and the shrinking labour market is forcing the municipality to face some difficult decisions. Most of the traditional economic sectors do not have particularly good future prospects, which means that new fields of enterprise and ideas have to be developed. The demographic goals are set up in the industrial policy programme from 1992 /10-9/. The negative population trend is to be reversed by the beginning of 1997 and is to be replaced by an increase entailing a population of more than 8,000 people in the municipality. Furthermore, the skewed gender distribution must be counteracted and the proportion of young women increased.

To achieve these goals, the municipality is focusing its efforts on a number of areas. One way to stop the emigration of young people is to offer as broad a secondary-school education as possible in the municipality. Certain secondary-school courses were therefore started in the autumn of 1994. The proportion of the population with a higher education varies between 5 and 20% in different parts of the municipality. The highest proportion of persons with a higher education is in Tärna. Otherwise, twenty-percent levels can usually only be found in the vicinity of university towns (Swedish National Atlas – Population /10-10/).

10.3 BUSINESS ENVIRONMENTAL ANALYSIS

This section is an abstract of "Storuman on the eve of the new millennium – an business environmental perspective" /10-3/.

The municipality and its trade and industry structure

Storuman is characterised by long distances within the municipality; long even in relation to the county and the rest of the country. Before the Gunnarn-Arlanda regular flight connection was started in 1993, Storuman was one of the country's most isolated municipalities. Storuman Municipality contains four parts with different business and employment structures:

- Storuman/Stensele, which has become the centre in terms of industrial activities;
- the district around Gunnarn in the southeast, which is dominated by agriculture and forestry;
- Tärnaby and Hemavan in the mountains, which have a tourism base;
- the intermediate district between Storuman and Tärnaby, which is very sparsely populated.

The traditional base is forestry and timber products which, despite far-reaching rationalization measures, still employs approximately 370 people directly or indirectly (12% of the jobs as against 8% in the county and 7% in the nation). State aid programmes aimed at increasing the value added in timber processing have had little result. Energy supply and infrastructure maintenance and expansion represent another major employment sector with about 500 jobs.

Public-sector positions provide jobs to about one-third of the employed population (roughly equal to the national average). The municipality's own administration accounts for roughly half, while other jobs are incorporated in a national system where important parts of the terms and funding are determined by the national government through decisions in which the municipality itself has little say.

A large portion of the state transfer payments are linked to the size of the population and how it changes. This means that the municipality automatically gets dwindling resources as the population diminishes.

The tourist industry is vulnerable to fluctuations in private purchasing power, the weather situation in central Sweden and the exchange rate for the krona in relation to the Norwegian and Finnish currencies in particular. The short season also means that they have to at least break even during some ten or so winter weeks between February and the end of April. Because of this dependence on tourism, the capacities of other service sectors in the area are in many cases planned for a larger customer base than the local population. Changes in the influx of travellers therefore have effects, both positive and negative, on the other service industries in the area as well.

Generally speaking, the economy in the tourist-based sector is very weak and there is a high dependence on different types of state and municipal aid. There are ambitions to expand the tourist sector by means of market development measures in the form of, for example, better flight connections to Finland, Norway and the Stockholm area, and by building up a summertime base as well. So far, however, it remains to be shown whether such efforts can survive without large state or municipal subsidies.

A dilemma for a rural municipality in the interior of Norrland is that the local market is too small to support a large and competitive business sector. The dynamics entailed by local competitive pressure is therefore lacking.

The large industrial companies are branches or subsidiaries in corporate groups whose top management is located elsewhere. The only enterprises headquartered in the municipality are the sawmill in Stensele, Storumans Industri AB, and New Forest Innovation AB in Forsvik. The energy sector is dominated completely by Vattenfall. Among builders, the National Road Administration and Kraftbyggarna (Vattenfall) account for the biggest investments. There are, however, numerous smaller local companies. The retail trade has "external owners" for the Konsum grocery stores, the filling stations and the car dealerships, and as far as transport and communications are concerned, SJ (Swedish State Railways), the National Rail Administration, Sweden Post and Telia account for most of the activity. All of the state-run enterprises are managed from afar, as are the county council's health care units, even though they have local boards.

Altogether, units under direct external management account for at least 750 employees in the municipality. Aside from the municipal sector, these are the enterprises of predominant importance in each sector. Other enterprises and companies must to a high degree adapt their operations to the rules and conditions established by the larger units. The companies operate under stiff competition from abroad, which gives them very limited means to influence their situation.

Business leaders, entrepreneurs and new business ventures

The absence of a stable, locally rooted small business structure makes it difficult to finance new business ventures for entrepreneurs who want to capitalize on a business idea. The shortage of risk capital is often pointed out as a big problem which could even be the stumbling-block for new investments if the municipality were to try more actively to stimulate new locally based business ventures.

Private companies are heavily dependent on the initiatives and decisions made by the entrepreneur who owns and runs the company. If he should become ill, suffer an accident or die, many of the companies would have to shut down altogether.

Internally generated new business ventures will not provide a sufficient base for Storuman in the future. Not, that is, if the inhabitants of the municipality wish to have the same standard of living as the rest of the country and to keep up with the rest of Europe as well. A further expansion of existing businesses, combined with the decision of some big companies to set up operations here, would appear to be necessary.

The municipal economy

The municipality has an economic situation typical of the rural municipalities with a relatively weak local tax base and large resource infusions in the form of state transfer payments. At the same time it has high costs due to climatic factors and a low population density.

Table 10-3 shows the municipality's total net costs per inhabitant compared with tax revenues, financial expense and necessary depreciation. In the table, "Rural municipality" represents an average of the Swedish rural municipalities.

The table shows that the municipality has a poorer point of departure than the average rural municipality, as well as the average for the municipalities in Västerbotten County. What is worrying is that the municipality has high costs for those activities that should be self-financing; there Storuman has a net cost of nearly SEK 2,400 per inhabitant.

Table 10-4 shows the costs in kronor per inhabitant for some of the municipality's principal areas of activity. On the whole, Storuman's expenses per inhabitant for leisure and culture, housing, education, child care and welfare are lower than the national average and significantly lower than the average for the Swedish rural municipalities. This may be a competitive advantage in a situation where the state transfer payments are being steadily reduced.

A summary assessment is that Storuman's municipal economy is apparently fairly well managed and many activities are managed at comparatively low costs. But the situation is probably very vulnerable and the available options for cutbacks and

Table 10-3. Economic data for Storuman (SEK per inhabitant during one year).

	Municipality's net cost	Business activity net cost	Total net cost	Taxes and transfer payments	Financial expense and depreciation	Change in equity
Storuman	-18,274	-2,384	-20,658	24,458	-3,502	297
Rural municipality	-19,283	-293	-19,576	24,382	-3,306	1,498
AC county	-18,557	-317	-18,874	24,154	-3,600	1,678
Nation	-15,822	253	-15,569	18,889	-2,570	747
Municipality in % of nation	116	-942	133	130	136	40

Source: What are the costs in your municipality, SCB 1992

Table 10-4. Storuman's costs for certain areas of activity (SEK per inhabitant during one year).

Area	Comprehensive school	Other education	Child care	Other welfare	Leisure, culture	Environment, rescue
Storuman	5,471	2,591	2,975	8,760	1,429	743
Rural municipality	6.402	2,735	3,725	11,032	2,341	913
AC county	6,357	2,855	3,701	9,864	2,847	783
Nation	5,604	2,575	3,987	9,273	2,108	616
Municipality in % of nation	98	101	75	95	68	121

Source: What are the costs in your municipality, SCB 1992

priority re-allocations are presumably small. The service commitment is great in relation to the very limited scope of the activities.

In short, Storuman is in a very precarious economic situation. Based on this, the conclusion is drawn that Storuman Municipality cannot take any further reductions in the population base without the municipal economy virtually collapsing, in the absence of significantly increased transfer payments from the national government.

In the long run, Storuman, like most other municipalities in the country, therefore has to plan for a situation with stagnant tax revenues and sharply rising costs. In combination with a weak long-term trend for local industry, the municipality therefore has a rather bleak economic future. The restraint in undertaking new commitments which the municipality has already been forced to observe will probably have to be further increased during the rest of the decade. Storuman is in great need of an aggressive industrial policy and influx of additional resources from the outside.

Storuman at a crossroads

The conclusion is that Storuman has come to a crossroads and must make a choice. The given conditions are unfavourable with a steadily declining (and ageing) population and a weakening of the municipal economy. Furthermore, it must be assumed that the "automatic" transfer payments from the state will decline.

One alternative is to accept a "low-budget profile" and adopt further belt-tightening measures. This would mean that the municipality would have adopted a policy that would lead to further emigration and a further thinning-out of municipal activities, as well as company closures. This should not be interpreted as a disaster scenario. A positive interpretation is instead that Storuman would capitalize on a small-scale image and local specialities.

An alternative is to go in for an "integration profile", i.e. that Storuman shall be a part of a market-oriented economic growth trend. The present-day industrial programme has such a profile at its foundation, but it will probably not be possible to carry out without substantial state resource contributions. Above all, efforts are needed to make the municipality attractive for big investments, in order to create the necessary stability and reverse the downward spiral. Small resource infusions and renewal based on local entrepreneurs is all well and good, but this will not suffice to reverse the trend.

A half century of activities at a deep repository would give the municipality entirely new prospects for reversing the trend. There is no other conceivable siting today that would have such long-range effects on the employment situation.

Since the question of a deep repository's impact on tourism has been raised, this risk must naturally be discussed and taken into account. However, there is no reason to making too much of this risk. There are no indications that there is any connection. Tourism on Öland is flourishing unabated, in spite of the nearby Oskarshamn Nuclear Power Plant. The same can be said about Forsmark.

Finally, regardless of what happens with a deep repository, some important basic prerequisites can be noted for the "integration profile" alternative:

- education at the upper secondary school level must be strengthened and must become more industrially/vocationally oriented;
- air connections with Stockholm must be maintained;
- the municipality must be more connected along a west-east axis by means of stronger integration with Mo-i-Rana and Umeå.

Furthermore, the content of the next industrial programme should make a point of encouraging and giving further training to the entrepreneurs that are active in the municipality.

It is also inevitable that resources must be concentrated on certain segments of business and industry. Considering the present-day structure, an obvious suggestion would be investments in the timber-processing sector and a further development of tourism. A reservation is warranted for both of these segments, however. The timber-processing sector requires very large investment resources, which are not available today. Tourism also requires investments, although probably on a smaller scale. However, the prospects for mass tourism in Storuman are unfavourable, and such tourism is probably undesirable anyway. A more likely scenario is to build further on the "niche" profile that tourism in Tärnaby/Hemavan already has today.

In conclusion, the prospects for a further development of information technology and long-distance communications should also be noted. The investment requirement here is much less, since a functioning infrastructure already exists. On the other hand, this is a popular idea today. Most Swedish municipalities are trying to profile themselves within this sector today. In other words, Storuman has to both find its niche and continue to develop its communication services. Otherwise there is a great risk that Storuman will miss out here, just as it did during the relocations within the manufacturing industry during the 1970s.

10.4 SOCIOECONOMIC CONSEQUENCES

This section is based on "Socioeconomic consequences of a deep repository for spent nuclear fuel in Storuman Municipality" /10-2/. In conclusion, a brief account is also given of the results of the supplementary survey "The future in Storuman/Stensele – Employers in focus /10-6/.

Economic development of Storuman without a deep repository

To determine how the development of the population and employment in Storuman may be affected if a deep repository for spent nuclear fuel is established in the municipality, an estimate of how these factors will develop without a deep repository is first needed. The reason is that the size of the indirect effect of the activities at the deep repository is not completely independent of the alternative course of events without a deep repository. The indirect effects on employment and population are, for example, influenced by how much free capacity exists today in the local service industries. With a steep downward population trend, an overcapacity can be expected to exist, which reduces the increase in the number of jobs the deep repository would otherwise have generated. In the same way, the presence of many jobless people in the municipality reduces the need for bringing in labour from the outside. In the long run, however, such effects will be lower than in the short run.

The reference scenario without a deep repository is based on the following assumptions:

For the three industrial sectors agriculture/forestry, manufacturing and tourism, it is assumed that most of the demand is outside the municipality. Production and employment are therefore not affected on the demand side by changes in the local population base. Employment in these sectors is assumed to change as follows:

- agriculture/forestry declines by 3% per annum up to 2000, thereafter by 1% per annum;
- manufacturing declines by over 2% per annum up to 2000, thereafter by 0.5% per annum;
- tourism-related employment increases by 0.25% per annum.

For all other economic sectors it is assumed that the demand mainly exists within the municipality. Production and employment therefore follow changes in the population base.

The number of jobs per municipal inhabitant changes as follows in the reference scenario:

- construction declines by 2% per annum up to 2000, thereafter by 0.25% per annum;
- commerce declines by 1% per annum up to 2000, thereafter by 0.25% per annum;
- transport and communications declines by 1% per annum up to 2000, after which the number of jobs increases by 0.25% per annum;
- private services, excluding tourism, increases by 0.25% per annum;
- public services declines by 2% per annum up to 2000, after which the relative share remains unchanged.

Figure 10-3 shows how the number of jobs in the economic sectors would change up to 2080 with these assumptions, in combination with previously described assumptions of how labour will be re-allocated.

From a maximum of 3,600 persons in 1985, employment falls according to the projection by nearly 1,500 persons during the period, i.e. to less than half the original level. This may appear drastic, but the time period is long. During the most recently observed five-year period (1985-1990), employment declined from more than 3,666 persons to 3,270 persons, i.e. by more than 2% per annum. During the projected period 1990 to 2080, the total number of jobs declines by an average of

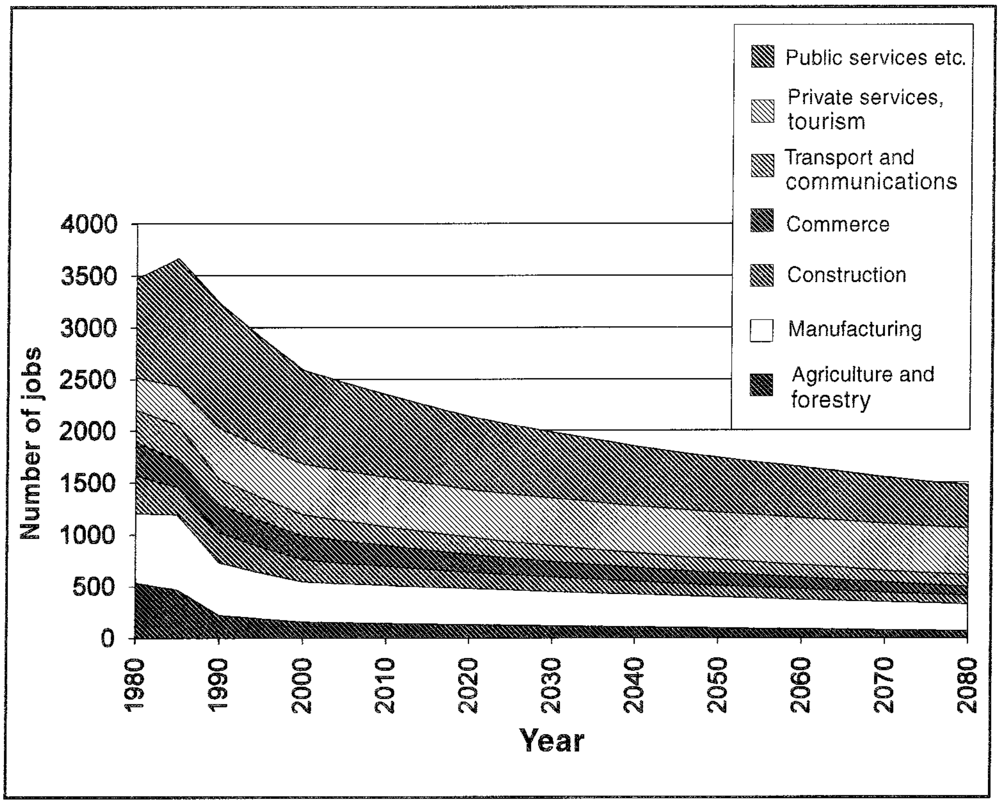


Figure 10-3. *Forecast: Total number of jobs in Storuman Municipality broken down among economic sectors – without a deep repository.*

0.9% per annum. Thus, with the assumptions made concerning the trends within the different economic sectors, the rate of decline during the forecast period is less than one-half of the rate currently observed. Based on structural conditions currently known, the chosen forecast estimate gives a slightly optimistic picture of the course of events.

Employers have better opportunities to find the skills they are looking for in localities where the educational level of the populace is high. Based on this assumption, Tärna, whose population is highly educated, would have the best population development in Storuman.

Local effects of the deep repository

The cost of a deep repository is estimated at about SEK 15 billion. This money generates employment directly at the deep repository, but also at the next level in the value-adding chain, in the companies chosen to deliver goods and services in connection with construction and operation. Furthermore, the customer base for the local service industries increases. How large the direct local share of the total value added will be has been shown to vary. The investment projects previously studied exhibit a range of between 11 and 60% local procurement.

The total cost of SEK 15 billion consists of roughly equal parts labour and material costs. Some of the largest cost items in the material category, besides sand and bentonite clay, are different types of machines, explosives and electrical installations.

The bulk of the costs in the beginning will be spent on construction of the surface section of the deep repository plus improvements and expansion of harbour, railway and roads. The emphasis will gradually shift to the underground section. It has been assumed in the calculation model that the largest costs (nearly SEK 4 billion) will arise during the period 2005-2009, when, for example, the road and railway sections will be built.

To permit calculation of the direct local employment effect, i.e. the effect generated solely by the deep repository, an estimate must be made of the components of the investment. Based on relatively detailed data from SKB, the component items have been analyzed in order to estimate the portion that will be a local cost, a local value added. The range in the estimates is great, varying between a few to a hundred percent. For example, it is assumed that the wage costs for construction on the site will be completely absorbed locally. In contrast, the wage costs for design and manufacture of process equipment will probably generate small local effects, since these activities are done elsewhere. Without exception, items characterized by material purchases are estimated to have lower local effects than items including wages.

After the local shares are estimated, these resources are allocated to different economic sectors. Not unexpectedly, the contribution to the construction industry is greatest. In total, the local share is estimated to amount to SEK 4.9 billion, which is just over 32% of the total cost of the deep repository. Compared with the results obtained from other investment studies, this percentage can be considered rather high. Translated to jobs, the locally absorbed investments generate on average about 245 jobs per annum over a period of 50 years, or a total of 12,250 job-years, see Table 10-5.

Table 10-5. Forecast: Direct local employment increase in job-years per annum, broken down among economic sectors. (1 = manufacturing, 2 = construction, 3 = commerce, 4 = transport and communications, and 5 = private service).

Period	1	2	3	4	5	Totalt
1995-1999	0	32	6	0	1	40
2000-2004	1	66	15	0	3	84
2005-2009	4	516	111	13	5	649
2010-2014	12	79	14	21	2	128
2015-2019	10	107	19	21	1	157
2020-2024	33	170	42	21	4	270
2025-2029	33	162	38	21	6	260
2030-2034	33	167	39	21	6	267
2035-2039	33	141	35	21	5	234
2040-2044	23	149	58	19	14	263
2045-2049	0	35	28	27	7	98
Total number of jobs	906	8,126	2,022	921	274	12,249

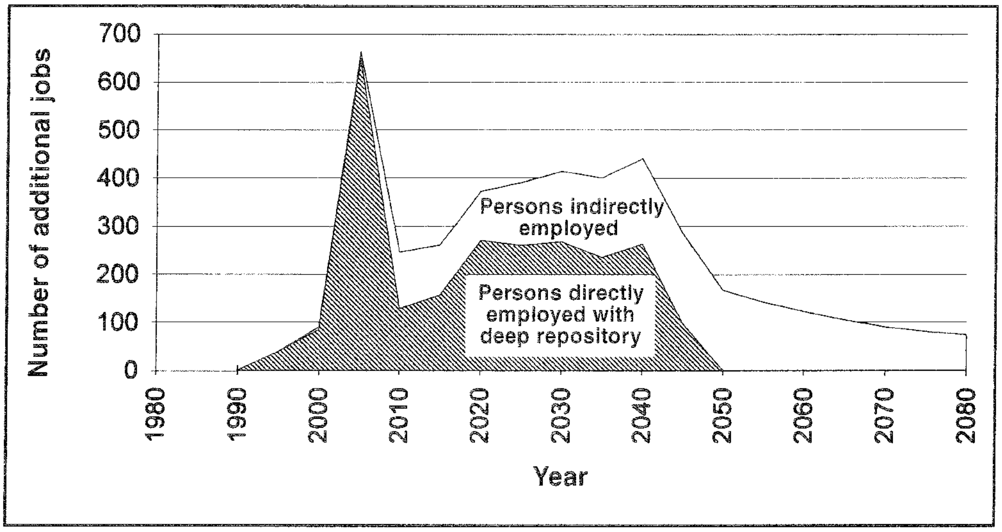


Figure 10-4. Forecast: Total number of jobs created by deep repository, broken down between persons indirectly employed and directly employed with deep repository.

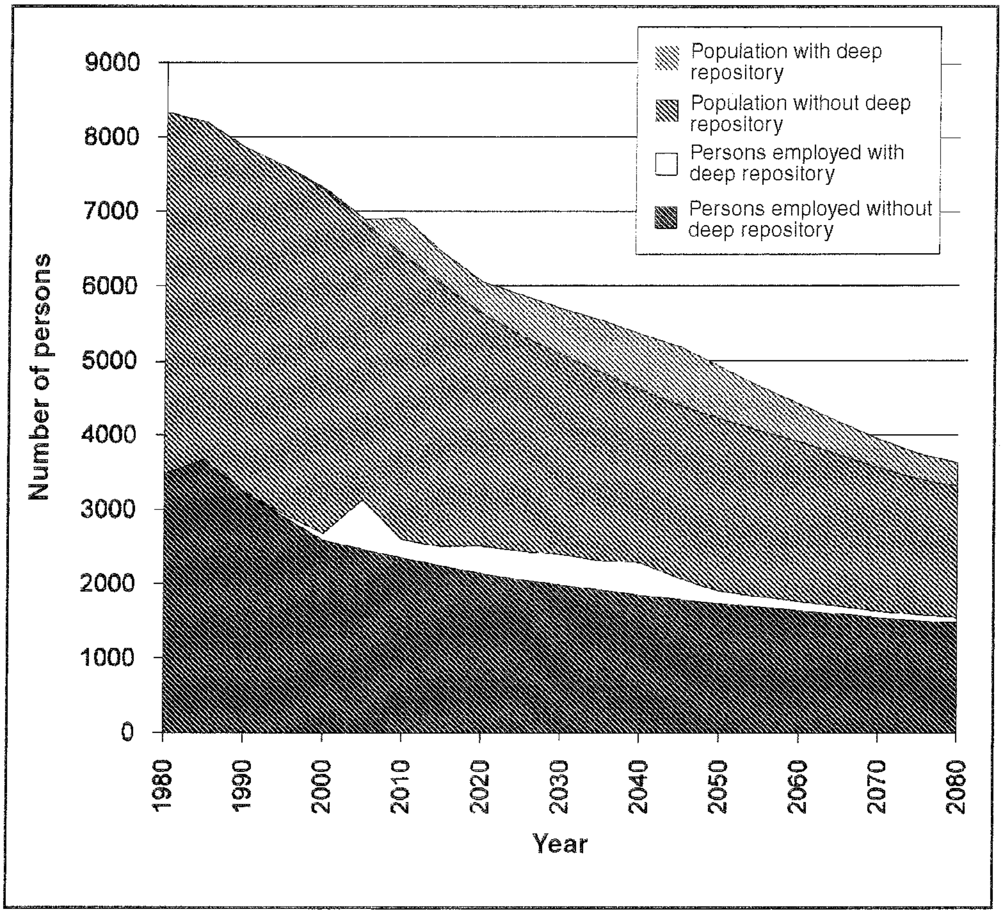


Figure 10-5. Forecast: Population and total number of jobs in Storuman with and without deep repository.

Economic development of Storuman with a deep repository

A comparison between the projections without versus with a deep repository shows that the population will still be larger at the end of the period, 30 years after the end of the deep repository era, if the facility is built. This is because the extra population corresponding to the level of activity during the deep repository era will not move away immediately after the end of the operation period. The difference will be greatest during the final phase, i.e. during the 2040s, when the population is estimated to be nearly 800 persons greater in comparison with the reference scenario. On average an additional 480 persons will live in the municipality during the period 2000-2050. A deep repository siting will not be sufficient to reverse the downward trend, but it will slow it down to some extent.

As far as the employment trend is concerned, the biggest difference occurs between 2005 and 2009 when at most an extra 660 job-years are generated as an effect of the deep repository. Figure 10-4 shows direct and indirect employment effects (number of jobs created) of the deep repository. The direct effect of the deep repository amounts on average to about 245 job-years when the projection is related to the 50-year period in question. The indirect job increment is estimated to be about 110 job-years on average during the period.

As the figure shows, the indirect employment effects do not ebb out during the forecast period, but extend even further ahead in time. This is because, as was discussed above, more service employees are needed to serve a still-larger population than in the reference scenario. This means that the employment effects of the deep repository in Storuman span more than a hundred years. Figure 10-5 summarizes the estimated population and employment level with and without a deep repository.

The description of the development of population and employment in Storuman with and without a deep repository is based on long-range forecasts composed of a number of five-year periods. It is therefore not possible to draw any far-reaching conclusions regarding individual years, or fluctuations between them, based solely on the figures.

For example, the relatively pronounced peak during the initial construction phase (around 2005 in Figures 10-4 and 10-5) has been found to lead to many questions concerning e.g. the relationships between population and direct and indirect employment. A temporary employment peak is reached during the construction period lasting about 3 years. A considerable portion of the more than 600 job-years during this short period have to do with the infrastructure (harbour, roads and railway etc.) and therefore lie in part outside the municipality. Furthermore, experience shows that much of the other labour requirement during the construction period will be met by commuting (day and especially week commuting). The effect on the population during this short period will therefore be, as the figures show, much smaller than is indicated by the employment peak.

The future in Storuman/Stensele – Employers in focus /10-6/

The study is based on a questionnaire sent out to all employers in Storuman/Stensele with the exception of the municipality, the county council, Vattenfall and Samhall/SAFAC. In all, 250 letters were sent out with a reply deadline of one week. The response frequency was 117, i.e. nearly 50%, and the replies are distributed over different sectors. The intention was to study more closely the beliefs of the local employers concerning their own companies and the local business community as a whole – without a deep repository versus with a deep repository. Some interviews were also conducted to complement and check the outcome of the questionnaire survey.

Without a deep repository, more than 50% of the employers are pessimistic regarding the future outlook for their companies. Less than 10% of the employers are optimistic. Many consider the chances of creating new jobs, as well as the prospects of running their own company in Storuman in 10 years' time, to be doubtful. Most negative are construction and transport companies, while manufacturers and consultants are more positive than average.

Assuming that the deep repository is built in Storuman, the employers have a different attitude. The proportion who have an optimistic view of the future increases from 10% to 50%, while the proportion of pessimists decreases from over 50% to 25%. Those who change their attitude from negative to positive believe that a deep repository would increase opportunities for new service companies, that tourism would increase and that new jobs would be created. Two out of three believe that with a deep repository in Storuman they will be able to run their own company in 10 years.

10.5 PSYCHOSOCIAL ASPECTS

This section is based on "Psychosocial effects of a deep repository for spent nuclear fuel" by J Garvill and G Weissglas, which is a study included in Umeå University's main report concerning socioeconomic consequences /10-2/.

The review of previous comparable experience shows, together with the course of events in Storuman, that the reactions to the feasibility study are by no means unique. The mass media, especially the local press, have played a central role in the dissemination of information.

The project has aroused strong opposition, and a clear polarization has occurred. Organized groups both for and against the feasibility study have been formed. It is obvious that portions of the populace feel greatly concerned about what will happen to the community and to their own living circumstances. This local concern has also found expression in adjacent municipalities, as well as in other parts of the county that will be affected by shipments of radioactive materials. The Sami have expressed their concern for the consequences of the deep repository for reindeer herding, although there has not been any more extensive debate concerning conflicts between reindeer herding and the deep repository.

As expected, the arguments in favour of a deep repository have mainly revolved around economic gains, jobs and general positive effects for the community. It has also been maintained that the facility in itself could be a popular tourist destination. A patriotic aspect has also been advanced: It is the obligation of the part of the country best suited for the purpose to host the facility for final disposal of radioactive waste, for the good of the country as a whole.

The other side claims that the technology is untested, that there are risks to health and the environment, and that there is a great risk that stigmatization effects will occur, i.e. that the district associated with the facility will get a bad reputation. There could be negative effects for tourism, both in the immediate area and more peripherally. The Tärna region is particularly mentioned, but fears that all of Västerbotten County could be affected have also been voiced.

The debate has made much of what are seen to be differences of opinion between experts and authorities regarding safety and risks. This lack of agreement serves as fuel for the arguments of those who are against a deep repository.

Incidents have occurred which further reinforce the perception of risk. An earthquake was registered in the county, something which created uncertainty as to what effects such an event could have on waste deposited in a deep repository. Civil disobedience actions have been perpetrated: A load of garbage was dumped outside the municipal building, and veiled threats of further actions have been made.

As long as no final decision has been taken and people still believe they can influence the decision, a high level of activity can be expected. This can be seen as an expression of people's attempts to find an outlet for the stress and anxiety they feel through direct action. Experience from other parts of Sweden shows that local action groups can be active over a very long period. The opposition to SAKAB's facility in Norrtorp is one example, the vigil at Kynnefjäll another.

Possible negative effects on the community as a result of a higher level of economic activity and employment have not been mentioned in the debate; the positive sides have dominated here. However, it is well documented that sudden increases in employment also have negative social effects: Both the hydropower construction period in the northern interior of Sweden and experience from Norwegian oil fields provide examples of this.

Since the interests of the Sami people in this context have been given very little attention in the debate thus far, it can be expected that their opinions will be aired in the future.

In summary, the investigators point out that there is every reason to take the local opposition seriously. It is quite apparent that groups in the community experience stress and anxiety at the prospect of both a decision on the deep repository and its consequences.

There are also positive psychosocial effects to consider. They are primarily associated with the positive labour market effects and the increased economic activity entailed by the establishment of a deep repository.

It is not possible to quantify either positive or negative psychosocial effects of the siting of a deep repository. However, both positive and negative psychosocial effects should be considered, along with other factors, in making a decision.

10.6 IMPACT ON TOURISM

The importance of tourism and the travel sector for the municipality and the region, in combination with previously expressed apprehensions on the part of the tourism industry regarding the consequences of a deep repository establishment, have led to special attention being devoted to this part of the economy and its special problems in the feasibility study's socioeconomic surveys. It has been stated that not just the possible impact on today's tourism, but also consequences of importance for the potential for future development must be considered.

As mentioned in the beginning of the chapter, three tourism studies have been conducted in the feasibility study:

- **Tourism and nuclear waste in Storuman Municipality /10-4/.** By Christina Olsson at the Department of Economics at Umeå University under the supervision of Professor Lars Hultcrantz.
- **Development of tourism in Storuman and southern Lappland with or without a deep repository.** A study conducted via interviews by Turismutveckling AB in Östersund describes the tourist industry's viewpoint.

- **Future development of tourism – assessment criteria.** A forecast of the development of tourism globally, nationally and regionally (Norrland and Västerbotten) compiled by the Mitthögskolan in Östersund.

The results of the two last-named supplementary studies are presented in a report entitled "Development of tourism" /10-7/. The results of the above mentioned studies are described below. The section concludes with experiences of the impact of nuclear installations on nearby tourism.

Tourism and nuclear waste in Storuman Municipality

Most of the visitors in Storuman Municipality come from the county and its immediate environs and visit the municipality to meet relatives and friends or to spend time at their weekend cottages. Since the waste shipments will probably go by train through the county, it is not likely that visitors will feel that a visit in Storuman is associated with any more direct risk than staying in their home municipality. For those who visit the municipality to see relatives and friends or spend time at their weekend cottages, there is no direct substitute or alternative destination. This also makes it likely that this group of visitors will not be affected to any appreciable extent.

The group that may possibly be affected the most is the group of potential visitors who are considering visiting the municipality at some time in the future. For this group of visitors there are many destinations to choose between, and a facility for the disposal of nuclear waste may in this context be a negative attribute for the municipality. The fact that the municipality is very large and that the facility will probably not be anywhere close to any major tourist destination may have a calming influence on those who perceive the facility as threatening. Nature-dependent tourism is of great importance for the municipality and it is therefore important that the facility should not spoil the experience of unspoiled wilderness the tourists expect from a visit to the municipality.

At the same time, it can be presumed that this facility, which may be one of the first of its kind in the world, will be of great interest to new groups of visitors, both Swedish and foreign. Examples of such new groups of visitors are schools, companies, journalists, research scientists, public officials and politicians, which thus will provide an additional influx of visitors to the municipality.

Development of tourism in Storuman and southern Lappland with or without a deep repository

The survey consists of two parts. The first part describes the history, current situation and development potential of the tourist industry. In the second part, representatives of companies and organizations of the tourist industry in Storuman Municipality, Norrland, Sweden and other countries are interviewed on what impact they believe a deep repository would have on their own business and on tourism in Storuman/Norrland.

A majority of those asked have a negative or ambivalent attitude towards a deep repository in Storuman and its consequences for tourism in Västerbotten and southern Lappland. The ones who are directly negative are mainly those companies and travel agents who have been marketing Norrland as Europe's last wilderness for some time now. They believe that this image will no longer be credible in relation to other destinations in the event a deep repository is built and that tourism in Norrland will suffer a great setback.

At the same time there is a smaller group who views the establishment of a deep repository positively. These businessmen do not believe that their customers will be influenced, or they believe there will be a decline of tourism during a limited space of time but that it will then recover. "As is evident, there are no objective or one-sided judgements of how the tourist trade will be affected by a deep repository. It depends to a very great degree on how the information is handled and perceived in the future, both internally and externally".

Several international observers have pointed out the important role played by the mass media. The judgement of the mass media is in turn dependent on the attitude of the local population. If the people who live in the area where spent nuclear fuel is to be disposed of trust that nothing will happen and feel safe, they convey this feeling to both the media and guests. Some experts believe that the press will influence tourism to a very high degree and others that the issue will mainly be debated locally.

It is assumed that a deep repository, if one is built, will lie in the eastern part of the municipality. In this part there are positive effects of a deep repository on the tourist industry in the form of increased business travel, mainly within the hotel and restaurant trade, which must be weighed against negative effects on nature-based tourism. Business travel is steady, occupancy is more year-round and will probably consist of financially stronger customers. Moreover, the slack periods in occupancy will be probably be during weekends, holidays and vacation periods, which leaves vacant capacity during the most attractive holiday travel periods. The travel which would be generated by visitors to a deep repository is more difficult to assess.

The picture for the Tärnaby/Hemavan area is different. Here the tourist industry believes that the positive effects from increased business travel will be marginal, at the same time as the negative consequences of a deep repository on the area's nature tourism will be great. What makes the area particularly vulnerable is tourism's large volume and importance today, and the fact that it is located in the same municipality as a possible deep repository and will therefore tend to be linked with it.

Future development of tourism – assessment criteria

The popularity of certain destinations or types of trips changes very slowly. The trend breaks have previously been triggered to a great extent by price and currency rate changes and have led to shifts in travel frequency between countries offering similar attractions. Transitions from sun and sea destinations to places of more cultural interest have been discussed for a long time. Urban tourism and ecotourism are current examples of budding trends, but are still of marginal importance compared with traditional travel. Even though environmental aspects are becoming increasingly prominent, both for business and industry in general and for tourism, questions remain as to when and if ecotourism will ever become an important form of tourism. The concept of ecotourism includes the fact that the tourist is supposed to contribute towards diversifying the local economy, at the same time as tourism should not become a dominant factor in the area's development.

Tourism is expected to increase in Europe in the future, albeit at a more modest pace compared with other parts of the world where travel opportunities have been limited in the past. In Sweden, the big cities, particularly Stockholm, are by far the most important destinations. It is not likely that there will be any significant increase in domestic travel in Sweden, since most people can and do travel already.

The peripheral location of Sweden, and particularly Norrland, poses special problems for the development of tourism. Several surveys have shown that interest in the interior of Norrland is considerable, but has not led to actual visits to a corresponding extent.

The investigator describes possible scenarios that indicate the strength and weakness of the interior of Norrland as a tourist destination. Today's heavy dependence on the domestic and regionally limited market leaves two alternatives open for expansion:

- a general increase in total tourism on domestic and overseas markets so that marginal, but still sufficiently large, groups choose this region as an interesting destination. The degree of interest depends on factors such as accessibility in terms of time and cost from the more distant markets, access to sources of information and booking opportunities. Other factors are the region's marketing efforts and the actual as well as perceived availability of attractive products that are competitive in relation to similar destinations;
- a tourism which to an increasing degree is based on new types of preferences and thereby different patterns of behaviour. If a long-term trend can be discerned where nature and the environment become more important, the interior of Norrland will presumably have better prospects for becoming an attractive destination, especially for foreign visitors. This situation, combined with a closer economic and social link to the European continent, ought to lead to better knowledge of Sweden and greater knowledge of the opportunities for tourism the country has to offer. The image Sweden already has should then strengthen interest in more remote parts of our country as well.

Experiences of the impact of nuclear installations on nearby tourism

Spent nuclear fuel is shipped regularly today between the Swedish nuclear power plants and the interim storage facility CLAB at the Oskarshamn nuclear power plant. Furthermore, there is a final repository for radioactive operational waste (SFR) at Forsmark. The Oskarshamn and Forsmark stations are located in sparsely populated regions. Ringhals (on the coast of Halland) and Oskarshamn (on the east coast opposite Öland) are situated directly adjacent to highly attractive areas for tourism.

All of this taken together means that, even though some caution is in order and direct comparisons are not always possible, the plants nevertheless have so many essential similarities with a deep repository in Storuman that comparisons are warranted.

The survey from Umeå University /10-4/ presents the results of discussions with tourist agencies in the municipalities where the Swedish nuclear power plants are located. It was found that no studies have been carried out in these municipalities of how the location of the nuclear power plants has affected tourism in the municipality/region. The extensive survey conducted among tourists in Kalmar County does not mention the fact that the Oskarshamn Nuclear Power Station is situated nearby. It is not possible to draw any certain conclusions, but it does not appear as if tourism has been affected to any great extent by the existence of the nuclear power plants.

The Swedish nuclear power plants are visited by a large number of people every year. Ringhals and Forsmark top the statistics with over 20,000 visitors per year each, of which about 30% are unbooked visits and the remainder are made by schools, companies, public authorities, politicians, journalists, etc. Approximately

10% of the total number of visitors come from abroad. Since the start in 1972, Ringhals has been visited by more than 430,000 people altogether.

A study of the REKO project "Nuclear waste disposal – threat or local development opportunity?" /10-11/ has dealt with the fears that a deep repository might have significant negative local or regional effects on, for example, the tourist industry. In order to obtain statistics as a basis for such a judgement, the prices of weekend cottages in Swedish nuclear power municipalities and their environs have been studied. The idea was that if a deep repository damages the image of a municipality or its surrounding region from the viewpoint of recreation, this should be noticeable in the form of lower prices for weekend cottages compared with other areas. The study showed that no such impact could be demonstrated in three of the four nuclear power municipalities. The exception was Kävlinge Municipality (Barsebäck). No impact on the price picture for permanent homes could be demonstrated in any nuclear power municipality.

10.7 REFERENCES FROM MAJOR CIVIL ENGINEERING PROJECTS

This section is based on the report "References from major civil engineering projects" /10-5/.

General

One way to get an idea of what socioeconomic consequences a deep repository establishment can entail is to study what experience other municipalities have of industrial establishments of a similar kind.

Politicians and public officials in several selected municipalities and counties were therefore interviewed and/or received a questionnaire with questions regarding their perceptions of the relevant industrial establishments. The replies were complemented with official statistics to obtain an idea of the trend in the municipality in question compared with the trend in the county/nation. The statistics come for the most part from SCB's (Sweden Statistics) database, SDB.

The industrial plants studied are the nuclear power stations in Forsmark, Oskarshamn and Ringhals, the Scanraff oil refinery, and SAKAB's plant for hazardous waste. The directly affected municipalities are Östhammar, Oskarshamn, Varberg, Lysekil and Kumla.

Demographics and education

The population trend in all municipalities was affected positively by the civil engineering projects, especially during the construction phase, Figure 10-6. The long-range effects are also positive, but less clear.

As far as age structure and educational level are concerned, all the studied municipalities appear to have had a similar profile from the start. The proportion of the population of working age and the proportion of persons with a higher education were slightly lower than the national average.

The statistics show a considerable increase of jobs for highly educated personnel at the nuclear power plants. However, the clear difference in educational profile for employees at different nuclear power plants suggests that many types of operation and maintenance work can be handled just as well by internally trained personnel as by newly recruited personnel with a higher education.

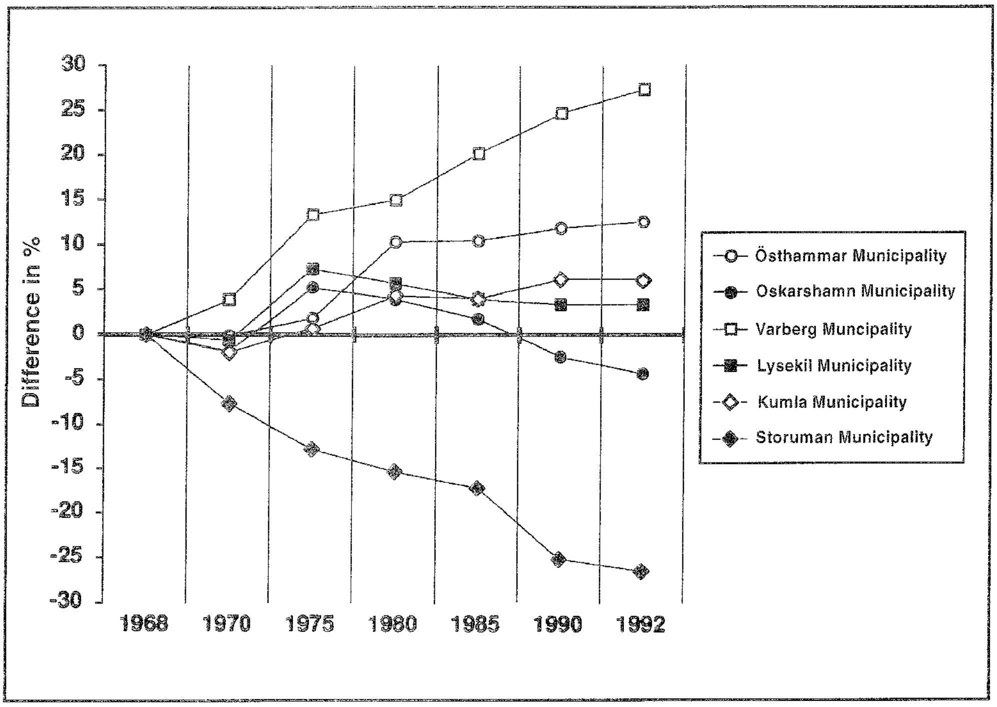


Figure 10-6. Population trend since 1968 in Storuman and studied reference municipalities in relation to the nation as a whole.

Jobs and local economy

Municipal officials judge that the civil engineering projects have been, and still are, of very great importance for employment. The percentage of the working-age population in the municipality that is directly or indirectly employed varies from a few percent for SAKAB to nearly 20% for Scanraff and Forsmark. These jobs include related business ventures in the form of service and maintenance companies. However, hopes of consequential ventures of other businesses, aside from service and maintenance companies associated with the plant, have not been fulfilled to any appreciable extent.

The advantage of a large and dominant employer seems to be that you get a powerful partner that can provide secure, qualified jobs and bring stability, knowledge and expertise to the region. Often, the activity also acts as an "locomotive" for the region. Potential disadvantages reported by municipal officials are in particular the consequences of a closure of the plant and the risk of a lopsided dominance of the local economy.

The effects of the plants on the tourist industry in the particular municipality are deemed to be insignificant in most cases. However, there are many examples of good cooperation in tourist matters between the municipality and the plant owner. A well-developed public relations and information operation is a tourist attraction in itself, especially in inclement weather. The plants are also often popular destinations for study visits by schools, public authorities, etc. Many plant owners also make large contributions to cultural and leisure activities.

Municipal development

Large industrial projects mean jobs opportunities and an increase in the region's economic strength and social activities. Like the construction of hydropower plants, the projects have a labour-intensive construction phase in the beginning. If the supply of qualified construction workers is limited within the municipality, extensive external recruitment is required. The rapid growth of population during the construction phase can put a heavy strain on the municipality's finances, especially if unutilized capacity in housing, services etc. is small.

For the municipalities, it is the subsequent operation and maintenance phase that provides long-term employment, stability and development potential. To avoid the problem of unemployed construction workers, attempts have been made in several cases to retrain a portion of the construction personnel to qualify them for operation and maintenance jobs. Newly hired operating personnel have to a large extent been relatively young and well-educated with families. This population addition contributes to a positive development of the municipality in many ways. Besides generating a greater demand for housing and private and public services, after an initial integration phase, it also gives rise to increased activities within e.g. culture, sports and association life.

An industrial establishment means increased tax revenues for the municipality thanks to the immigration of labour and the often relatively high wage level in the companies. Up to 1980, the municipalities could also count on significant income from property tax, since the plants have high assessed values.

Many municipalities have also been able to improve the financial yield of the plant establishments by signing development and cooperation agreements with the developer. This enables the municipality to cover special costs incurred by the plant establishment, but it can also be a more general compensation or source of extra revenue. Examples of areas regulated by agreements are rescue services, housing construction, education, road construction and sponsoring of sporting, cultural and leisure activities.

The plant establishments have often had a positive impact on the educational system and the infrastructure in the municipalities, and in some cases also on health care. No direct negative effects have been mentioned by municipal officials.

Cooperation and settlement of conflicts

The companies and concerned municipalities have had disputes and conflicts with local opinion-makers and other competing interests during the period preceding the construction of the plants, but today the mood is characterized by widespread acceptance. There is a general belief that the advantages outweigh the disadvantages. Cooperation between companies and local authorities has reportedly been good or very good for all projects. There is no general method for solving conflicts, but the importance of informing the public in good time and in a credible manner has often been emphasized.

Conclusions from other industrial establishments

The special premises existing in Storuman Municipality and the special character of the deep repository are such that caution must be observed in drawing direct parallels between the socioeconomic consequences of an industrial establishment in southern Sweden and a deep repository in Storuman Municipality. Bearing this uncertainty in mind, however, the following conclusions can be drawn:

- population growth and employment level have developed favourably in the studied municipalities compared with other municipalities in the respective counties. This is particularly true during the construction phase. A positive view of industrial establishments also exists among politicians and officials in the municipalities;

- in all reference municipalities, the industrial plants have represented a considerable portion of the total number of job opportunities, especially during the construction phase. If external contracting and service work on the plants plus indirect employment in the community are included, the plants account today for more than 10% of the total number of jobs in all municipalities except Kumla Municipality. This is roughly equivalent to the importance of a deep repository for Storuman Municipality. The indirect employment effect of a deep repository may be slightly less, however, since the need for service and contracting personnel will be lower than for process-based plants;
- experience from the reference municipalities suggests that a deep repository could provide many direct and indirect job opportunities that could contribute to stable development in the municipality. This is particularly true in view of the fact that the activities are to continue for more than 40 years. With the planned relatively slow pace of expansion, there are good chances that the problems of a large temporary construction workforce can be avoided. For example, operation of the facility should largely be able to be handled by local professionally trained personnel, supplemented by a certain portion of imported young and well-educated engineers and researchers.

10.8 PROSPECTS WITH RESPECT TO SOCIETAL ASPECTS

Criteria/factors

The siting of a deep repository shall be carried out in stages involving a democratic decision-making process. The social and socioeconomic consequences shall be explored by conducting studies of e.g. population development, socioeconomics, repercussions for the local economy, and labour market aspects.

Storuman Municipality

Storuman is a typical sparsely populated municipality in the interior of Norrland with vast open spaces. It has been experiencing considerable problems with unemployment and depopulation for several decades. The labour market is stagnant in the basic economic sectors of agriculture and forestry, including wood-processing and hydropower. An exception is the mountainous areas around Tärnaby and Hemavan in the western part of the municipality, where the growth of the tourist industry has enabled the population to remain relatively stable through the years.

A deep repository in the eastern forested part of the municipality would, when fully operational, provide about 200 direct and 100 or more indirect jobs, which would correspond to nearly 10% of the number of persons employed in the municipality today. Nearly 500 more persons would live in the municipality between the years 2000 and 2050 with a deep repository than without one, according to a forecast by researchers at Umeå University. The same study estimates that more than 30% or about SEK 5 billion of the total cost of SEK 15 billion could be absorbed locally. No alternative establishment of equivalent size or with equally long-range employment effects has been identified.

Tourism will probably not be affected overall by a deep repository, according to an assessment performed by another researcher at Umeå University. Certain parts of the nature or wilderness tourism sector might possibly be affected by declines, but this could be offset by new categories of visitors to the deep repository from

Sweden and abroad. Another survey performed by Turismutveckling in Östersund shows that there are persons within the tourist and visitors industry who have a differing view – that a deep repository will spoil the image of Lappland as a virgin wilderness and thereby have a negative impact on tourism within a considerably larger region than the municipality itself.

An examination of previous somewhat comparable experience from siting of the Swedish nuclear power plants, the SAKAB hazardous waste plant and the Scanraff oil refinery in Lysekil show that opposition has been strong in the beginning, but that the attitude today is characterized by a widespread acceptance. Tourism has not been affected, and population growth and employment have developed favourably.

According to the survey from Umeå University, the prospect of a deep repository in Storuman Municipality has aroused concern among portions of the populace. Organized groups both for and against the project have been formed. This concern has also found expression in adjacent municipalities and in the county, owing in part to a negative attitude towards radioactive waste shipments. The Sami are worried about the consequences for reindeer herding.

During the feasibility study, SKB has noticed that the question of the impact on tourism is of great importance to many in the region. Opinions differ widely and it is really not possible on purely objective grounds to say with certainty what the impact would be actually be. It is worth mentioning that the volume of business travel to a deep repository would be great. A large number of engineers, researchers, regulatory inspectors, journalists etc. from both Swedish and other countries will visit or work temporarily in the facility. This type of visit and business travel already occurs to SKB's existing facilities, and the scope for the deep repository will probably be at least as great. Finally, SKB notes that there does not seem to have been any negative impact on tourism in the regions surrounding the existing nuclear power plants. The impact on tourism has been discussed abroad in conjunction with sitings of nuclear facilities, but the actual outcome has not entailed a setback for the tourist industry in any known case, and quite the contrary in some cases.

11 EVALUATION

This chapter summarizes and evaluates the results of the feasibility study. The chapter also contains a discussion of whether it is interesting to continue, and if so when and how.

11.1 SUMMARY EVALUATION

Good technical prospects exist for siting, building and operating a deep repository in the municipality of Storuman. However, assessments of long-term safety and constructability require additional knowledge concerning conditions in the bedrock at a depth of about 500 m. Based on what is known from the surface and from existing rock facilities, however, there is a good prognosis that continued investigations will succeed in pinpointing large rock volumes that meet the requirements.

Four large granite areas have been studied more thoroughly than other parts of the municipality. Of these, two – Olbon at Blaikfjället and the area at Norrberg – have proved to be more heterogeneous than the existing geological maps indicated. Even though this does not have to be negative for a deep repository, it increases uncertainty regarding what conditions are like at depth. Furthermore, both areas are situated near areas of interest for mineral prospecting.

In contrast, no directly unsuitable conditions have been found in the two granite areas Joran and Lumsen. The Joran area is large, about 90 km^2, well-exposed and consists entirely of granite. Available data indicate that the granite is homogeneous, fracture-poor and has relatively few fracture zones. The Lumsen area as well presumably contains large volumes of homogeneous and fracture-poor granite, particularly its northeastern part at Lycksaliden. However, the degree of exposure is low and the area is smaller than Joran. There are indications of large rock displacements (neotectonic faulting) in connection with the retreat of the continental ice sheet near Lumsen, which should be further examined if continued investigations are undertaken in the municipality.

From a viewpoint of land use and environment, the conditions for a deep repository are generally favourable in the eastern part of the municipality. Except for the valley of the Ume River, there are few other land-use interests and ample opportunity to completely avoid intrusion in nature and culture protection areas. A review of the suitability of the four geologically interesting areas with respect to land use and environment has not identified any definite obstacle to a siting. However, Olbon appears to be the area in which the risk of conflicts with competing interests are greatest. The area in which a siting is judged to entail the least disturbance is the Joran area. The size of the area should make it possible to site the surface facility with its connecting railway so that consideration is given to land owners, nearby residents, reindeer herding, forestry, active outdoor recreation, etc. The impact of a deep repository in the Joran or Lumsen area on active outdoor recreation is judged to be small.

All things considered, Joran holds out the best promise, and Lumsen the second-best, as an area worth continued study. The areas are marked in Figure 11-1. There are roads and railways of good standard near these areas that can be utilized for the waste shipments to the deep repository. Rail shipments from a Norrland harbour to

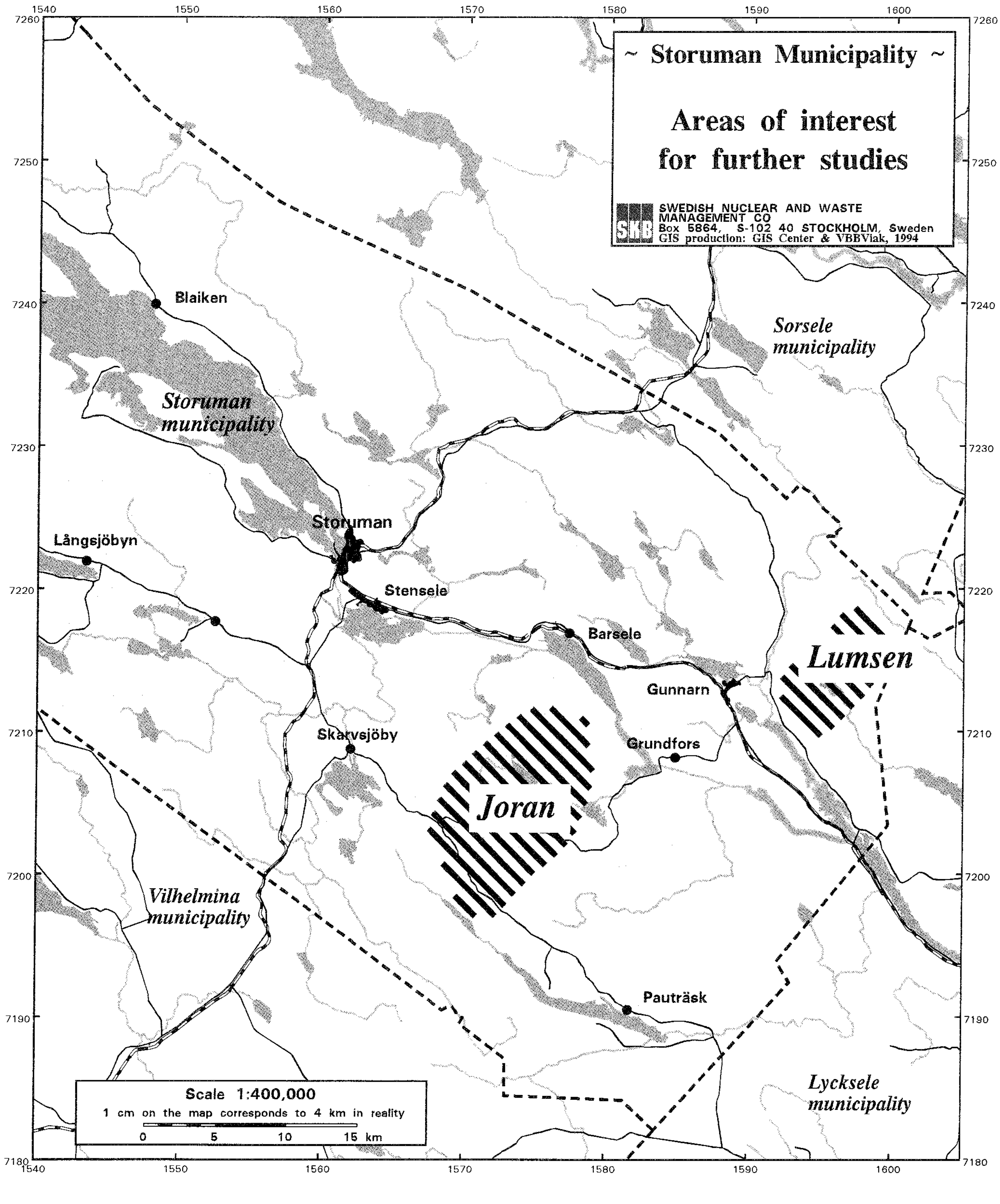


Figure 11-1. Areas of interest for further studies. The Joran area is given top priority. The size of the underground portion of a deep repository is about 1 km^2, i.e. an area of about 2.5 x 2.5 mm on the map. The area needed for the surface facility is smaller, about 0.3 km^2.

the municipality can be performed in an efficient and safe manner at relatively low cost. The technical opportunities for expansion are deemed to be good for a terminal in, for example, Skelleftehamn or Umeå outer harbour. Needs and costs for connections by road or rail from a deep repository to an existing rail line will be explored in the event of a continuation of siting investigations in Storuman.

In the socioeconomic surveys, assessments have been made of what consequences, both positive and negative, a deep repository may have for the population, employment situation and business community in the municipality. Most investigators are agreed that the levels of employment and population will be higher with a deep repository than without. But opinions differ regarding the impact of a deep repository on tourism.

Consequences for reindeer herding can be limited if areas of national interest are avoided when siting the deep repository. However, reindeer herding may be affected even outside these areas.

11.2 POSSIBLE CONTINUATION

Before a continuation can be considered by SKB, the results of the feasibility study in Storuman must be compared with the results from feasibility studies of other municipalities. As mentioned previously, between 5 and 10 such feasibility studies, similar to the one in Storuman, are planned. The selection of areas for site investigations will also be placed in a national context with the aid of the general siting studies of all of Sweden that will be reported in collective form during 1995. This means that the studies in Storuman have now essentially been concluded in this phase. Certain supplementary information may, however, have to be gathered by SKB in connection with the municipality's independent review and any questions that thereby come up. Otherwise it will not be until results have been obtained from other feasibility studies that a continuation in Storuman can be considered for SKB's part.

In the event of a continuation, the Joran granite, and possibly the Lumsen granite, should first be investigated with regard to their depth, occurrence of water-bearing fracture zones, and hydrochemical and rock-mechanical conditions. Furthermore, it should be investigated whether significant rock movements occurred in the region in conjunction with the retreat of the most recent continental ice sheet. If so, a study should be conducted to ascertain what new movements of this kind during the end of the next ice age could mean for a deep repository in the municipality.

An initial answer to the above questions can be obtained by means of geophysical ground investigations and the drilling of a few boreholes with associated borehole measurements, plus trench excavations at suspected faults. The results obtained from the boreholes would also provide answers to other questions concerning e.g. radon and rock stresses at repository depth. The results of these investigations will determine whether it is interesting to continue with complete site investigations in any area. Examples of other studies that should be conducted at an early stage are analyses of how the Joran and Lumsen areas are situated in relation to groundwater flow on a local and regional scale, as well as what impact a possible future mining operation in the surrounding region could have on the chemistry and flow of the groundwater. The geoscientific studies should be supplemented with inventories of fauna and flora and a survey of areas of particular interest for active outdoor recreation, reindeer herding and forestry.

Needs and costs for connections by road or rail from a deep repository to an existing rail line will be explored in the event of a continuation of siting investigations in Storuman. In conjunction with a possible future site investigation, an environmental impact assessment (EIA) will be carried out. The forms for this work (the EIA process) should be established before a continuation of the studies in the municipality.

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Appendix 1

SYSTEM FOR ENCAPSULATION AND DEEP DISPOSAL

(Excerpt from study circle material entitled "Facts & Questions & Thoughts")

How will the spent fuel be disposed of?

After interim storage for about 40 years in CLAB, Central interim storage facility for spent nuclear fuel, the spent fuel will be disposed in a deep repository located about 500 m down in the Swedish bedrock. The method that was accepted as safe in 1984 by the Government is called KBS-3 and is based on containment of the fuel inside multiple barriers. These barriers are chosen and designed to isolate the fuel from its surroundings for a very long time.

Description of method

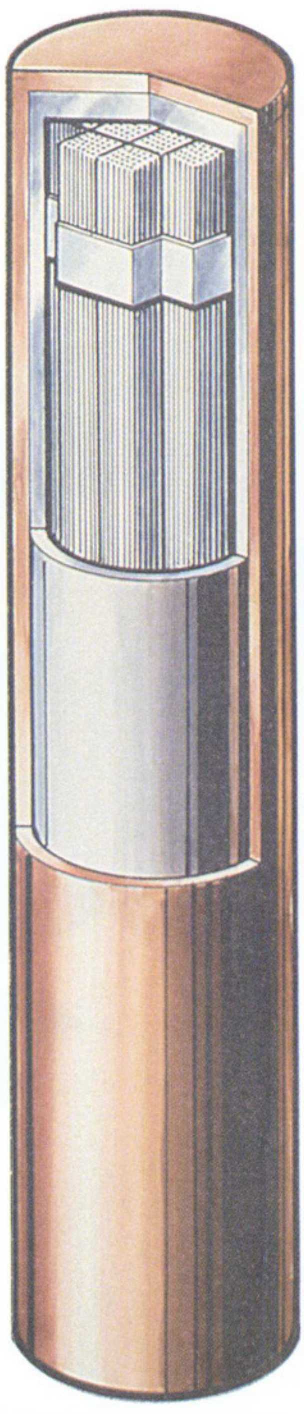
Before deposition in a deep repository, the spent fuel assemblies are encapsulated in cylindrical copper canisters with inner steel containers. The canisters are then emplaced in a repository built at a depth of approximately 500 m in the bedrock. In a system of tunnels, vertical holes are bored and in each borehole a canister is emplaced. Each canister is surrounded by hard-packed bentonite clay. When all fuel is in place, the facility are closed and sealed by backfilling all tunnels and shafts with a mixture of bentonite clay and sand.

After closure, the groundwater slowly starts to penetrate the repository and resume its natural level near the ground surface. The only way radionuclides could be transported from the repository is by groundwater, but several barriers prevent this.

Protective barriers

1. The fuel itself is a barrier. It consists of uranium in solid ceramic form, which has extremely low solubility in the groundwater at depth.

2. The canister of copper with an inner steel container isolates the fuel from the groundwater for a very long period of time. At the depth of 500 m there is no free oxygen that can react with the copper canister. Small quantities of substances dissolved in the groundwater can give rise to very slow corrosion of the copper shell, but it takes at least a



Cutaway view of copper canister with inner steel container.

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Ingår i studiematerialet Fakta, Frågor & Funderingar (febr 1994)

million years for this corrosion to make holes in the canister. After such a long time, the radionuclide content in the fuel is not more harmful than what naturally occurs in the bedrock.

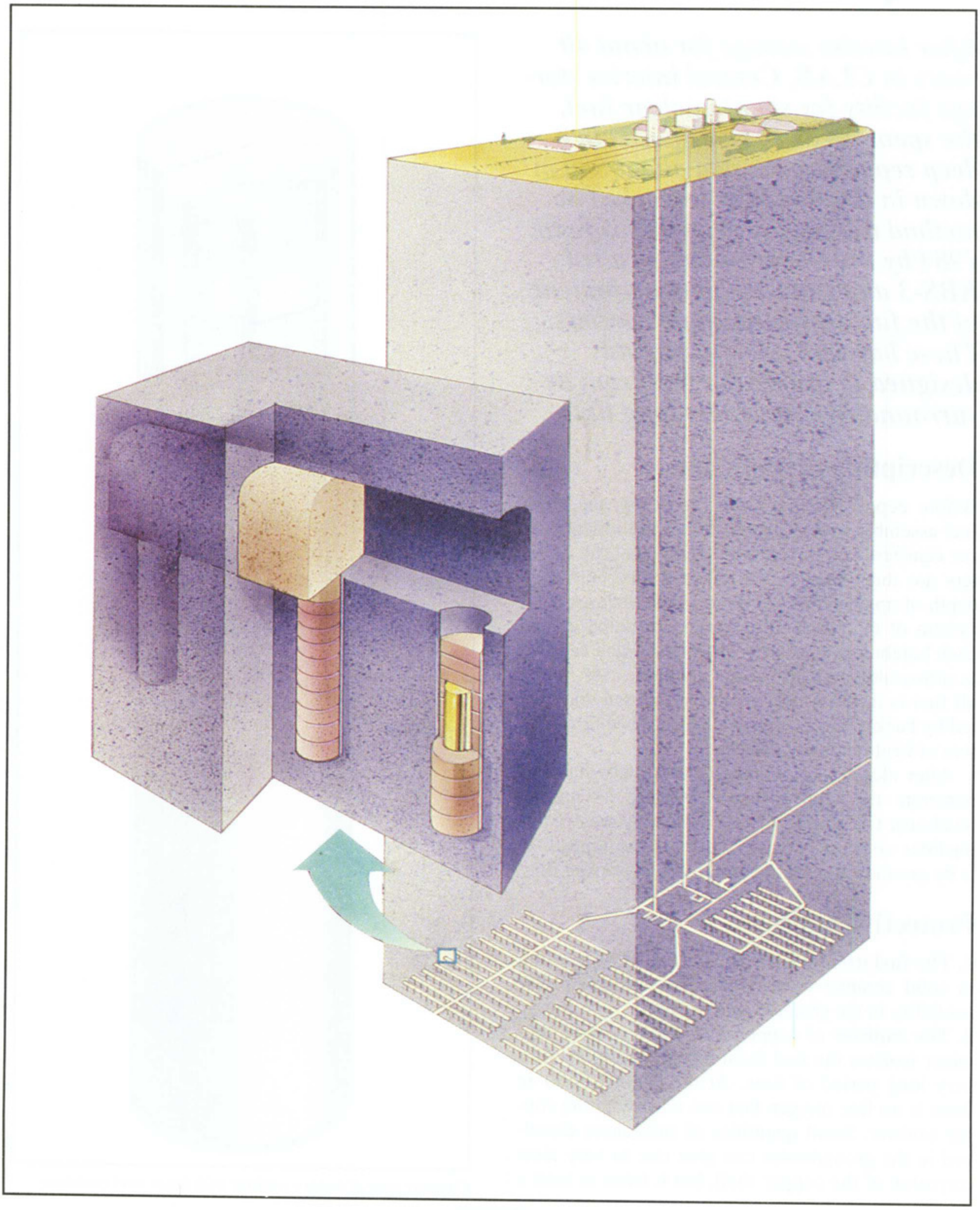
3. The bentonite clay around the canister and in the tunnels swells on contact with water, thereby filling up all the space between the canister and the rock. Besides preventing groundwater movements, the clay also protects the canister against minor movements in the rock.

4. The rock around the repository offers a stable environment, both chemically and mechanically. It protects against damage caused by both natural and human forces. If radioactive materials should nevertheless escape from the canister, both the bentonite clay and the rock act as "filters" which retain and retard the transport of radionuclides.

Surveillance

When the repository has been closed, no further surveillance, maintenance or attention is necessary. However, future generations have the option of providing some surveillance or retrieving the fuel to handle it differently.

The fuel is protected by multiple barriers: 1. The fuel itself 2. The canister 3. The bentonite clay 4. The rock



How will the fuel be encapsulated?

Before the spent nuclear fuel is emplaced in the deep repository, it will be encapsulated in durable canisters. The canister is one of the most important barriers in the deep repository, since it is expected to keep the fuel isolated from the groundwater for a very long time. The canister also facilitates handling of the fuel in conjunction with deposition in the deep repository.

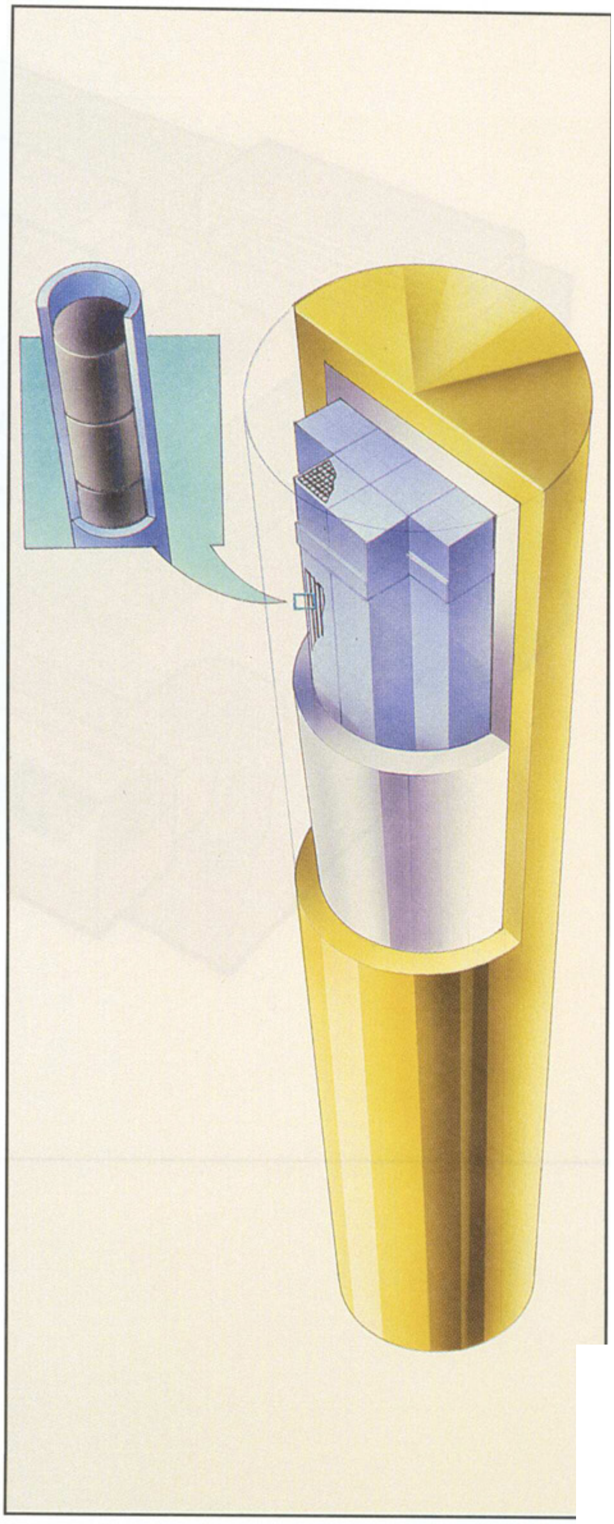
The most important requirement on the canister is that it shall remain intact for a very long period of time in the deep repository. It shall not corrode (rust) in the groundwater present and shall withstand any mechanical forces which it is subjected to.

Canister material

The canister is planned to consist of an inner container of steel, which provides mechanical strength, and an outer canister of copper, which provides corrosion protection. Copper corrodes very slowly in the oxygen-free environment at 500 m depth in the Swedish bedrock. Studies show that the canister probably will remain intact for a million years, i.e. much longer than the 100,000 years during which the spent fuel is more harmful than a rich uranium ore. Other designs of the canister have also been studied previously.

Encapsulation

Encapsulation is planned to take place in a new plant connected with CLAB. In the encapsulation plant, fuel will be received from CLAB's storage pools and will then be placed in a canister after being checked and dried. Before the lid is placed on the inner steel container, the void in the canister may be filled with e.g. glass beads and inert gas. The copper canister will then be sealed by using electron beam welding. The weld will have very high requirements and will be tested thoroughly. After inspection to make sure the canisters are tight and clean, they will be transferred to a shielded buffer store before being transported to the deep



Schematic drawing of canister for spent nuclear fuel. The canister is 5 m long and has a diameter of 88 cm. The canis[ter] wall consists of 5 cm of steel and 5 cm of copper. With fuel [the] canister will weigh about 15 tonnes.

Utgiven av SKB, Svensk Kärnbränslehantering AB
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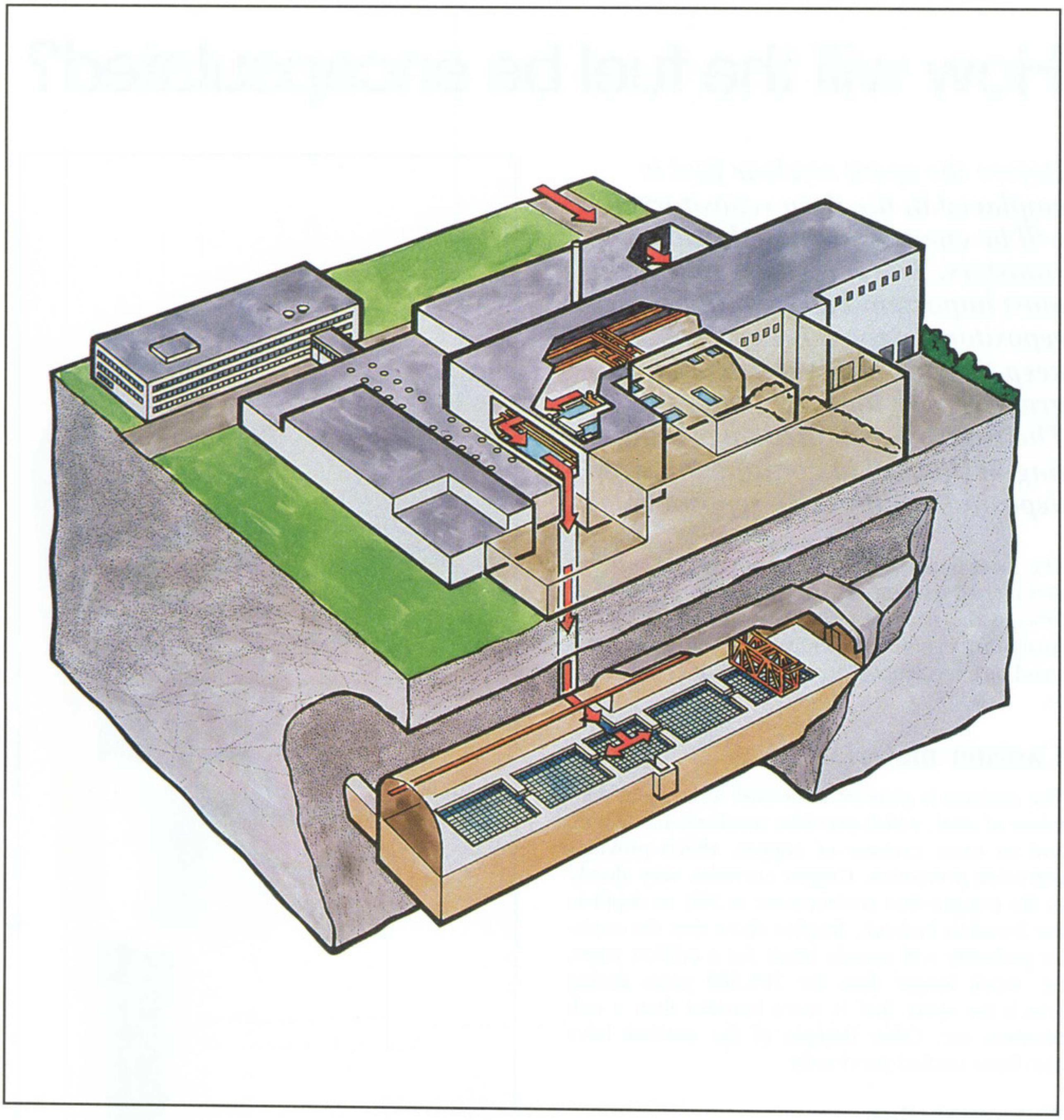
repository. Transportation will take place in transport casks of the same type as those used today for the shipments of spent fuel from the nuclear power plants to CLAB.

At a later stage, other long-lived wastes will also be treated in the encapsulation plant. Control rods and other internal parts of the reactor are examples of such waste and will be embedded in concrete moulds.

Encapsulation of the fuel is planned to take place in a new plant connected with CLAB.



COMPOSITION OF STEERING GROUP, REFERENCE GROUP AND PROJECT GROUP PLUS OTHERS WHO HAVE TAKEN AN ACTIVE PART IN THE FEASIBILITY STUDY WORK

Steering group

The work has been led by a steering group consisting of two representatives from the municipality, Erik-Abel Ejderud and Åke Gavelin, and two from SKB, Per-Eric Ahlström and Claes Thegerström. The chairman of the steering group has been Erik-Abel Ejderud.

The municipality's coordinator up to the summer of 1994 was chief environmental officer Christer Olin, since which time municipal CEO Stig Lindh has been in charge of coordination.

Reference group

A reference group has been assigned to the steering group. It is appointed by the municipal executive board and given the task of following the feasibility study work and offering viewpoints and suggestions. The reference group consists of 24 members, who represent the political parties, the County Administrative Board and non-governmental organizations. The reference group has met approximately every other month.

Moderate Party	Marianne Löfstedt *(Chairman)*
Centre Party	Tomas Mörtsell *(Deputy Chairman)*
Social Democratic Party	Roland Kärrman
" " "	Lena Drangel
Christian Democratic Party	Barbro Mörtsell
New Democratic Party	Edgar Sundin
Green Party	Märta Backlund
Liberal Party	Leif Semrén
Civil Defence League	Viola Ludvigssonn
Swedish Society for Nature Conservation	Leif Andersson
Youth Environmental Association	Anna Maria Johansson
Storuman Retail Federation	Pia Kristiansson
Federation of the Private and of the Prizes	Bengt-Håkan Viklund
Tourist Industry – Entré Lappland	Ronny Nyström
Young & Proud	Anna Linder
Storuman Utvecklings AB	Alf Tengström
Federation of Swedish Farmers	Kjell Rubertsson
Sami Villages	Inger Baer-Omma
County Administrative Board	Lena Nilsson
County Tourist Board	PG Johansson
Västerbotten Association of Local Authorities	Håkan Ottosson
Trade Union Confederation section	Erland Johansson
Forestry interests	Olle Lindh
Storuman Consumer's Cooperative Movement	Margareta Granström

Project group

A project group at SKB has been in charge of ensuring that the studies have been carried out in accordance with the instructions of the steering group. Kaj Ahlbom has been project manager and principal investigator for the geoscientific surveys. Other principal investigators have been Christer Svemar (facility design and transport), Erik Setzman (society and socioeconomics), Nils Kjellbert (environment and safety) and Gunnar Bäckström (information). Jerker Tengman has been responsible for administration and economical control and Håkan Jonsson for the information office in Storuman.

Management of databases and production of GIS maps have been presided over by Magnus Odin (VBB VIAK) and Karin Fridstrand (GIS Center). Susánne Persson has been in charge of records and secretarial services.

Investigators

The studies have been conducted by the following:

Conterra AB
Bengt Leijon

Ekonomisk Byggnation AB
Ann-Mari Ekendahl

EuroFutures AB
Carl Fredriksson
Lennart Stålberg

Geological Survey of Sweden
Thomas Eliasson
Kerstin Johansson
Rune Johansson
Robert Lagerbäck
Thomas Lundqvist
Gunnel Ransed
Lars Rodhe

Geosigma AB
Göran Nyberg
Stig Jönsson

GeoVista AB
Hans Isaksson

Golder Associates AB
Karl-Lennart Axelsson
Lars Hansen
Tommy Olsson

Kemakta
Lars Birgersson
Björn Lindbom

LangeArt
Fritz Lange

Mirab
Hardy Lindroos

Mitthögskolan in Östersund
Lars Nyberg

Saltech AB
Per Lindemalm

Storumans Utvecklings AB
Owe R Hedström

Svensk Geofysik AB
Anders Lindén

Turismutveckling AB
Malin Johnsdotter
Göran Lindgren

Umeå University
Nils Arell
Jörgen Garvill
Einar Holm
Urban Lindgren
Christina Olsson
Gösta Weissglas
Ulf Wiberg

Vattenfall Energisystem AB
Ebbe Forsgren
Erik Setzman
Lars Welander

VBB/VIAK
Robert Jönsson
Virpi Nõmtak

ÅF–Energikonsult AB
Sören Johansson

Ventilationstest
Gustav Åkerblom

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All reports available in Swedish only.

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Reports describing the geoscientific situation in the municipality	
Dec. '93	Description accompanying soil map of the Storuman area, K Johansson, G Ransed and L Rodhe, Geological Survey of Sweden. (PR 44-94-004)
Jan. '94	Storuman Municipality, geohydrological description, G Nyberg, S Jönsson, Geosigma AB. (PR 44-94-005)
Feb. '94	Storuman Municipality in a regional geological context, T Eliasson, T Lundqvist, Geological Survey of Sweden. (PR 44-94-003)
Feb. '94	Juktan pumped storage hydropower station. Summary of geological and hydrogeological information, K-L Axelsson, L Hansen, T Olsson. (PR 44-94-007)
Feb. '94	Ores and minerals within Storuman Municipality, H Lindroos, Mirab. (PR 44-94-008)
Apr. '94	Hydrochemical conditions, R Jönsson, V Nõmtak, VBB/VIAK. (PR 44-94-006)
Apr. '94	Description accompanying bedrock map of crystalline basement in Storuman Municipality, H Lindroos. SKB PR 44-94-009, April 1994.
Apr. '94	Geophysical documentation and interpretation, H Isaksson, GeoVista AB and R Johansson, Geological Survey of Sweden. (PR 44-94-010)

Published	Title
Apr. '94	Experience of rock construction in a regional and local perspective, B Leijon, Conterra AB. (PR 44-94-011)
Dec. '94	Geological reconnaissance and geophysical interpretation of interesting areas. H Lindroos, Mirab, H Isaksson, GeoVista, and R Johansson, and R Lagerbäck, Geological Survey of Sweden. (PR 44-94-035)

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June '94	Community planning and land use, E Setzman, Vattenfall Energisystem AB. (PR 44-94-016)

Reports describing the environmental consequences of a deep repository in the municipality

Jan. '94	Storuman Municipality – Brief environmental overview, S Johansson, ÅF-Energikonsult AB. (TPM 94-4471-01)
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Dec. '94	Impact of a deep repository on active outdoor recreation, S Johansson, ÅF-Energikonsult AB. (TPM 94-4471-04)

Reports describing possible transport modes and transport routes to Storuman Municipality

Jan. '94	Transportation of encapsulated radioactive waste to a deep repository – System and safety, A-M Ekendahl, Ekonomisk Byggnation AB. (TPM 94-4470-01)
June '94	Means of transport to a deep repository in Storuman Municipality, P Lindemalm, Saltech AB. (PR 44-94-012)

Reports describing possible facility design and manning of a deep repository plus radiological working environment

Nov. '93	Brief preliminary facility description, S Pettersson, C Svemar, SKB. (AR 44-93-008)

Published	Title
Dec. '94	Radiological environment at the deep repository and accident preparedness in connection with transport of radioactive waste, B Lindbom and L Birgersson, Kemakta. (PR 44-94-038)
Dec. '94	Radon in a deep repository, G Åkerblom, Ventilationstest and A Lindén, Svensk Geofysik AB. (PR 44-94-039)

Reports discussing socioeconomic consequences of a deep repository in Storuman Municipality

Jan. '94	Socioeconomic study programme, E Setzman, Vattenfall Energisystem AB. (TPM 94-4471-02)
Feb. '94	Tourism and nuclear waste in Storuman Municipality, C Olsson, School of Economics in Umeå. (PR 44-94-013)
May '94	Socioeconomic consequences of a deep repository for spent nuclear fuel in Storuman Municipality, E Holm (ed.), Umeå University. (PR 44-94-019)
May '94	Storuman on the eve of the new millennium – a business environmental perspective, C Fredriksson, EuroFutures AB. (PR 44-94-020)
May '94	References from major civil engineering projects, L Welander, Vattenfall Energisystem AB. (PR 44-94-021)
Dec. '94	The future in Storuman/Stensele – Employers in focus, Storumans Utvecklings AB / O R Hedström. (PR 44-94-040)
Dec. '94	Development of tourism. Collective report, L Nyberg, Mitthögskolan, and M Johnsdotter and G Lindgren, Turismutveckling AB. (PR 44-94-036)

Reports describing the work of the reference group

Dec. '94	Meetings of the reference group, its viewpoints and questions. (PR 44-94-037)

VIEWPOINTS OF THE REFERENCE GROUP ON THE STATUS REPORT

This report presents an account of the municipality's compilation of the viewpoints of the reference group on the status report published in June 1994 (SKB PR 44-94-025). The compilation was done by municipal CEO Stig Lindh.

A more exhaustive account of the viewpoints of the reference group is provided in the report entitled "Meetings of the reference group, its viewpoints and questions" (PR 44-94-037) (in Swedish only). The report contains complete copies of the statements of comment. It also contains SKB's replies and comments to the reference group's viewpoints and questions.

As is evident from this final report, some of the reference group's questions have been addressed in the supplementary surveys conducted during the autumn. However, the feasibility study has not been able to provide answers to all questions. Most of these will, however, be addressed if a site investigation is performed.

Feasibility study regarding final repository for radioactive waste in Storuman Municipality – compilation of statements of comment

At the expiry of the review period, 19 statements of comment had been received. No further statements have been received since that time.

The following bodies have commented on the status report:

The Trade Union Confederation section in Storuman
Federation of the Private and of the Prizes
The County Administrative Board
The Västerbotten County Tourist Board
The Storuman Retail Federation

The Swedish Society for Nature Conservation
Young & Proud
The Liberal Party in Storuman
The Christian Democratic Party in Storuman/Tärnaby
The Social Democratic Party in Storuman

The Centre Party in Storuman
The Green Party in Storuman
Marianne Löfstedt, Storuman
Kjell Rubertsson, Umnäs
Ronny Nyström, Storuman

Storuman Municipality, social services department
Storuman Municipality, public works department
Storuman Municipality, child welfare and education committee
Storuman Municipality, administrative section

The statements have been compiled according to subject area and follow the project organization for the feasibility study, with the addition of a few headings. The content of the statements of comment are summarized below.

Community planning and land use

Some concern has been expressed that a final repository will only involve male labour and that the municipality will meet the fate of a mining community. In-depth analyses of the impact of the final repository on tourism are lacking – but are in progress.

The final report should contain an overall evaluation of the four studied areas and be arranged in an easily readable fashion so that it fulfils the intentions of the environmental impact assessment (EIA). An account of the field excursion at the end of September 1994 should also be given.

If the feasibility study is followed up by a site investigation, in-depth comprehensive plans will be needed for the areas in question. As far as reindeer herding is concerned, an EIA can be postponed until a proposal has been put forth concerning the siting of the surface facility.

Socioeconomics

The statements of comment ask questions of the type:

- "How are young women in the municipality doing?"
- "What will happen if emigration cannot be stopped?"
- "Can we protect ourselves against the atomic garbage that has been improperly stored/disposed of in e.g. Murmansk?"

The feasibility study should be supplemented with a number of questions putting people in Storuman in the centre of focus.

Businessmen want to know what type of companies and services that are lacking today must be started/provided if a final repository is built. Can research on waste management be established in Storuman?

Some concern is also expressed that emigration will take place at a more rapid pace than is foreseen by the investigator in his scenario.

Information

The eternal information problem remains – the information that has gone out has not reached all in the municipality – the right pedagogical and public relations approaches have not been found. Requests are made for additional information, and young people feel neglected.

Facility design

The construction period allotted for the final repository is too short. It is necessary to "import" labour from the outside, which means that the local workforce will soon be out of work again. It is preferable to extend the construction period so that local builders will have work over a longer period.

How long the repository will be open and when it will be closed are not clearly specified. Demands are made for an open and guarded repository.

People also want more concrete answers on how surveillance and monitoring are to be done.

Transportation

Shipments to the final repository should go by rail. The question is asked as to what happens if a canister is damaged during transport and its contents exposed. How is such a situation to be handled, and what will the consequences be?

Geoscience

Site-specific groundwater calculations must be carried out for the four areas in question. Furthermore, the occurrence of industrial minerals should be determined in greater detail.

The area selected for a possible site investigation must be presented prior to a referendum.

Environment and safety

The safety aspects must take precedence. Eagerness on the part of one or more municipalities who need work to survive must not lead to a compromise of long-term safety. SKB should explain today how deposited waste can be retrieved, if this should be necessary. Additional information on radiation and radiation risks is needed. A simplified EIA should also be included in the feasibility study.

Economics

The independent review must be paid for by the state – for example, out of the reserves for managing and disposing of nuclear waste administered by SKI. Demands are also made on financial compensation for the municipality that "leases" its land for site investigation and detailed characterization on the order of at least SEK 15 million per year for a period of at least 5 years. A draft exploitation agreement should be prepared now.

Some concern is expressed about whether reserved funds will be enough, and the question is asked: "How will the future financing be provided otherwise?" A legal seminar during the first half of 1995 is proposed.

Other

Demands are voiced that SKB present the names of at least another five municipalities where feasibility studies will be undertaken before the referendum is held.

Greater involvement by national policymakers in the process of siting a final repository is called for.

A situation description of other country's strategies is called for.

A great deal of space is given to the work of the reference group in the statements of comment. Demands are made for a report from the group that can be distributed to the public. It is proposed to take different forms:

- like a government inquiry
- as special statements issued by individual members.

Negative judgements regarding the reference group and its work are expressed. A scandal and a flagrant example of pseudo-democracy: A travesty of democracy.

The feasibility study in Storuman itself cannot be regarded as being concluded until SKB has signed agreements for feasibility studies in at least five municipalities.

The municipality should be given access to map materials and other documentation produced during the feasibility study.

Demands have been voiced that the municipality sign legally binding agreements with the Riksdag (Parliament) and SKB that the outcome of the referendum shall be respected – otherwise, thank you and goodbye to SKB.

In the referendum we shall only vote "Yes" or "No" to a final repository for radioactive waste – nothing else.

The opinion has been offered that the summary of the feasibility study should not have been done by SKB, but by some independent body.

Finally, the opinion has been stated that no final repository should be established in Storuman Municipality and that all cooperation with SKB should cease.

INFORMATION RELATING TO THE FEASIBILITY STUDY IN STORUMAN

(October 1992 – December 1994)

(The list includes those activities in which SKB has participated)

Time	Activity
October 1992	• Letter from SKB with general information on RD&D-Programme 92 and the siting work to all municipalities in Sweden.
November 1992	• Storuman Municipality contacts SKB, which leads to an information meeting with the working committee of the Municipal Executive Board.
January 1993	• Study trip to SFR and CLAB. Participants from political parties, various organizations and associations. • Political parties are informed.
February 1993	• SKB's exhibition trailer visits the municipality for a week (about 700 visitors). • Information meeting for Municipal Council. • Information to the County Administrative Board.
March-April 1993	• Representative from SKB is on hand in Storuman and Tärnaby, one day a week at each locality.
March 1993	• Approx. 10 evening meetings with local associations. • Toll-free telephone line (020 number) installed.
April 1993	• Question of invitation to SKB to conduct feasibility study is tabled by the Municipal Council. • Debate on national radio.
May-June 1993	• Information meetings are held at five different places (Storuman, Tärnaby, Gunnarn, Slussfors, Långsjöby) in the municipality. SKB, SSI and SKI participate (about 80 persons attended). • Inland Fair – SKB's stand was visited by about 600 persons.
May 1993	• Information to the 10-municipality group in Västerbotten County (all inland municipalities in the county).
June 1993	• Decision by Municipal Council on feasibility study. • M/S Sigyn calls at 3 Norrland ports – 13,700 visitors.

Time	Activity
September 1993	• Agreement between SKB and the municipality on a programme for the feasibility study. • Reference group is established by the municipality. • Start of the various studies. • Hiring of person to be in charge of local office.
October 1993	• Reference group meeting. • Local office established. • Association meetings.
November 1993	• Open house at the local office. • Letter to the transit municipalities regarding shipments. • Mailing unit to all households with general information on the feasibility study.
December 1993	• Reference group meeting. • Association meetings. • Information to Environmental Department, Fire Department and Department of Public Streets in Umeå.
January 1994	• Reference group's study trip to SFR and CLAB. • Association meetings. • Information to Environmental Department, Fire Department and Department of Public Streets in Skellefteå. • Information to Municipal Executive Board in Skellefteå. • Public evening meeting on the shipments in Skelleftehamn (SKB, SKI, SSI and Greenpeace participated.)
February 1994	• Seminar for reference group on "Radiation and radiation protection" (representatives from SKB, SSI and Vattenfall.) • Evening lectures (Storuman, Tärnaby) on "Radiation and radiation protection" for the public. • Regional Youth Association for Environmental Studies and Conservation is informed. • Association meetings in certain neighbouring municipalities.
March 1994	• School information. • Municipal Executive Board and Council – letter regarding debate on feasibility study. • Debate programme on regional TV – "Radiant times". • Geoscience Day with Open House at local office. • Panel debate is held with SKB, Greenpeace, critics chosen by the opposition group, Dept. of the Environment, SKI, SSI. Attended by about 300 persons. • Folkhögskolan is informed. • Reference group meeting. • Information to Municipal Executive Board in Umeå.

Time	Activity
April 1994	• Seminar for reference group on encapsulation, encapsulation plant and shipments. • Evening lectures (Storuman, Tärnaby) on encapsulation and shipments for the public. • 10-municipality group is informed. • AMU receives information. • Association of Local Authorities is informed during a trip to Tärnaby.
May 1994	• Mailing unit to all households containing situation report. • Participation in seminar arranged by Young & Proud and Storuman Municipality. • Seminar for reference group on geoscientific characteristics. • Evening lecture on geoscientific characteristics for the public. • Health & Medical Care Fair in Umeå. SKB participates with exhibition. • Inland Fair in Vilhelmina. SKB participates with exhibition.
June 1994	• Seminar for reference group on socioeconomic consequences. • Evening lectures (Storuman, Hemavan) on socioeconomic consequences. • Presentation of status report to Municipal Council. • Reference group meeting. • Mailing unit to all households containing summary of results from all surveys. • Sigyn tour of five Norrland ports.
August 1994	• Reference group meeting. • Presentation of the status report to invited representatives of municipality's in the county. (Arranged by Association of Local Authorities.)
September 1994	• Two-day field excursion for reference group members to which media and the public were invited. • Reference group meeting. • Information meeting for adult educational associations active in the municipality.
October 1994	• Information and consultation meeting with representatives of Vapsten and Umbyn Sami villages. • School presentations at Malgomaj School in Vilhelmina. • Debate programme on TV Botnia.

Time	Activity
December 1994	• Youth group Veritas on study visit to CLAB and Äspö HRL. • Study trip for council and reference group members to CLAB and Äspö HRL.

The debate has been intensive ever since the municipality contacted SKB to discuss a feasibility study. It has been reflected in the regional media, in news articles as well as on the debate pages and in letters to the editor. The national media have also covered the issue. Altogether, there have been more than 1,000 items in the media on the subject during the period from January 1993 to December 1994.

List of SKB reports

Annual Reports

1977-78
TR 121
KBS Technical Reports 1 – 120
Summaries
Stockholm, May 1979

1979
TR 79-28
The KBS Annual Report 1979
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Summaries
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Summaries
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1983
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Summaries
Stockholm, June 1984

1984
TR 85-01
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Stockholm, June 1985

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Including Summaries of Technical Reports Issued during 1985. (Technical Reports 85-01 – 85-19)
Stockholm, May 1986

1986
TR 86-31
SKB Annual Report 1986
Including Summaries of Technical Reports Issued during 1986
Stockholm, May 1987

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SKB Annual Report 1987
Including Summaries of Technical Reports Issued during 1987
Stockholm, May 1988

1988
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Including Summaries of Technical Reports Issued during 1988
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Including Summaries of Technical Reports Issued during 1989
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Including Summaries of Technical Reports Issued during 1990
Stockholm, May 1991

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Including Summaries of Technical Reports Issued during 1991
Stockholm, April 1992

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TR 92-46
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Including Summaries of Technical Reports Issued during 1992
Stockholm, May 1993

1993
TR 93-34
SKB Annual Report 1993
Including Summaries of Technical Reports Issued during 1993
Stockholm, May 1994

List of SKB Technical Reports 1995

TR 95-01
Biotite and chlorite weathering at 25°C. The dependence of pH and (bi) carbonate on weathering kinetics, dissolution stoichiometry, and solubility; and the relation to redox conditions in granitic aquifers
Maria Malmström[1], Steven Banwart[1], Lara Duro[2], Paul Wersin[3], Jordi Bruno[3]
[1] Royal Institute of Technology, Department of Inorganic Chemistry, Stockholm, Sweden
[2] Universidad Politécnica de Cataluña, Departmento de Inginería Química, Barcelona, Spain
[3] MBT Tecnología Ambiental, Cerdanyola, Spain
January 1995

TR 95-02
Copper canister with cast inner component. Amendment to project on Alternative Systems Study (PASS), SKB TR 93-04
Lars Werme, Joachim Eriksson
Swedish Nuclear Fuel and Waste Management Co, Stockholm, Sweden
March 1995

TR 95-03
Prestudy of final disposal of long-lived low and intermediate level waste
Marie Wiborgh (ed.)
Kemakta Konsult AB, Stockholm, Sweden
January 1995

TR 95-04
Spent nuclear fuel corrosion: The application of ICP-MS to direct actinide analysis
R S Forsyth[1], U-B Eklund[2]
[1] Caledon-Consult AB, Nyköping, Sweden
[2] Studsvik Nuclear AB, Nyköping, Sweden
March 1995

TR 95-05
Groundwater sampling and chemical characterisation of the Laxemar deep borehole KLX02
Marcus Laaksoharju[1], John Smellie[2]
Ann-Chatrin Nilsson[3], Christina Skårman[1]
[1] GeoPoint AB, Sollentuna, Sweden
[2] Conterra AB, Uppsala, Sweden
[3] KTH, Stockholm, Sweden
February 1995

TR 95-06
Palaeohydrological implications in the Baltic area and its relation to the groundwater at Äspö, south-eastern Sweden – A literature study
Bill Wallin
Geokema AB, Lidingö, Sweden
March, 1995

TR 95-07
Äspö Hard Rock Laboratory Annual Report 1994
SKB
April 1995