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Biological variables for the site survey of surface ecosystems – existing data and survey methods

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Summary

In the process of selecting a safe and environmentally acceptable location for the deep-level repository of nuclear waste, site surveys will be carried out. These site surveys will also include studies of the biota at the site, in order to assure that the chosen site will not conflict with important ecological interests, and to establish a thorough baseline for future impact assessments and monitoring programmes. As a preparation to the site survey programme, a review of the variables that need to be surveyed is conducted. This report contains the review for some of those variables.

For each variable, existing data sources and their characteristics are listed. For those variables for which existing data sources are inadequate, suggestions are made for appropriate methods that will enable the establishment of an acceptable baseline.

In this report the following variables are reviewed:

Variable Group	Variable*
Humanity	Fishery
Physical geography	Landscape
Biota	Vegetation types
	Key biotopes
	Species (flora and fauna)
	Red-listed species (flora and fauna)
	Biomass (flora and fauna)
Hydrology	Water level
	Water retention time (incl. water body and flow)
	Nutrients/toxins
	Oxygen concentration
	Layering, stratification
	Light conditions/transparency
	Temperature
	Sediment transport

*Marine environments are excluded from this review

For a major part of the variables, the existing data coverage is most likely insufficient. Both the temporal and/or the geographical resolution is often limited, which means that complementary surveys must be performed during (or before) the site surveys.

It is, however, in general difficult to make exact judgements on the extent of existing data, and also to give suggestions for relevant methods to use in the site surveys. This can be finally decided only when the locations for the sites are decided upon. The relevance of the different variables also depends on the environmental characteristics of the sites.

Therefore, we suggest that when the survey sites are selected, an additional review is undertaken. This review would assess which variables, and respective data sources and methods, that are relevant at the respective sites and for the different parts of the project, i.e.:

- The final site selection process.
- The site surveys.
- The EIA-process.
- The monitoring programme.

Sammanfattning av resultaten

I arbetet med att välja en säkerhetsmässigt lämplig och miljömässigt acceptabel plats för djupförvar av uttjänt kärnbränsle, skall platsundersökningar genomföras. Dessa platsundersökningar skall även innefatta studier av lokalernas biota, för att dels säkerställa att den valda lokalen inte kolliderar med viktiga naturvårdsintressen och dels för att upprätta en god ekologisk kunskap om platsen för att underlätta framtida konsekvens- och säkerhetsanalyser och löpande miljöövervakning. Som en förberedelse till detta arbete genomförs en genomgång av de variabler som skall studeras.

För respektive variabel anges befintliga datakällor samt deras beskaffenhet. För de variabler där kvaliteten på befintliga kunskapskällor anses begränsade, ges också förslag på lämpliga tillvägagångssätt/metoder för att uppnå en acceptabel nivå av kunskap för att kunna genomföra platsundersökningarna på ett bra sätt.

I föreliggande rapport redogörs för följande variabler:

Variabelgrupp	Variabel*
Människan	Fiske
Naturgeografi	Landskapsbild
Biota	Vegetationstyper
	Nyckelbiotoper
	Arter (flora och fauna)
	Rödlistade arter (flora och fauna)
	Biomassa (flora och fauna)
Hydrologi	Vattenstånd
	Vattenomsättning (inkl. volym och flöde)
	Näringsämnen/gifter
	Syrehalt/-sättning
	Skiktning
	Ljusförhållanden
	Temperatur
	Sedimenttransport

*Marina miljöer är exkluderade ur detta material.

För merparten av variablerna kan konstateras att det befintliga dataunderlaget sannolikt inte är tillfyllest. Såväl den tidsmässiga eller geografiska upplösningen är i de flesta fall begränsad, vilket betyder att omfattande undersökningar måste genomföras under platsundersökningsprocessen.

Det är dock i många fall svårt att på ett definitivt sätt uttala sig om såväl omfattningen av befintliga data samt ge förslag på relevanta metoder för platsstudier. Detta kan i

detalj göras först när de platser som skall studeras är identifierade. De olika variablernas relevans i ett platsundersökningsprogram är också avhängigt de valda platsernas miljömässiga beskaffenhet.

Därför föreslår vi en ytterligare genomgång efter att lokalerna där platsundersökningar skall genomföras har valts ut. Denna genomgång resulterar i en anpassad variabellista, där relevanta variabler, inklusive befintligt dataunderlag samt metodförslag, för respektive plats redovisas. Dessutom kan man då även bestämma vilka variabler som är intressanta för de olika delstegen i djupförvarsprocessen, dvs:

- Det slutgiltiga platsvalet.
- Platsundersökningarna.
- MKB-processen.
- Övervakningsprogrammet.

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1 Introduction

SKB is planning to continue the siting program for deep repository of spent nuclear fuel in year 2001 with survey of, at least, two potential sites. These sites will be selected from six communities: Nyköping, Östhammar, Oskarshamn, Tierp, Hultsfred or Älvkarleby. Previous work has been to identify suitable areas in various communities in Sweden based on available data from various disciplines, mainly geology and transport possibilities. By analysing site characteristics it will be possible to point out the most suitable sites for siting program. The sites will survey for data relevant to evaluate the construction and function of a planned deep repository.

There are several fields of investigation preparing for the siting program. For example, have the geological investigations established a list of variables /Andersson et al, 1998/. Variables that might be of interest to investigate from an ecosystem point of view are presented in Lindborg and Kautsky /2000/. The final goal before the siting program is to establish a list of variables that should be investigated during field-surveys and a program on how these variables should be measured.

This report describes some of the variables that may be of interest to the surface ecosystems included in a siting program. It mainly concerns four groups of variables: humanity, physical geography, biota and hydrology. The specific variables in each group are described and reviews available data from each of the communities suggested for siting program. Other variables of interest to the surface ecosystems is presented elsewhere in separate reports /Blomqvist et al, in manus; Haldorson, 2000; Lindell et al, 1999/. The variables presented here represent a broad spectra of information, e.g. vegetation type, key biotopes, biomass, water-level, -nutrients and -temperature. For a major part of the variables the existing data is not sufficient and complementary surveys must be performed. There are at this stage, due to insufficient data, difficult to give suggestions for relevant methods to use in the site surveys. Final methods will be decided when the locations and the specific environmental site characteristics are settled.

2 Variable group Humanity

2.1 Fishery

The ***Variable fishery*** comprises data concerning fish stocks (fish and crayfish) in terms of species diversity. It also includes the use of lakes and running waters for fishery, i.e. fishery for both livelihood and recreation, but also aquaculture. This review is limited to fresh water lakes and watercourses.

2.1.1 Existing data

The following sources of data have been identified:

- *National sources:* National Board of Fisheries, Swedish EPA (Naturvårdsverket, SNV), Statistics Sweden (SCB).
- *Regional sources:* The county administrative boards (Länsstyrelser), mainly the divisions for fishery and/or nature conservation, the Board of Fisheries (Fiskeriverket) regional inspector offices and the universities. Some regional information is also available at the county agricultural societies and at some foundations (e.g. the Upplandsstiftelsen).
- *Local sources:* The municipalities (kommuner), fish management associations (FVOf), sport fishing associations and clubs.

Without knowing the exact locations of the survey sites, it is not possible to state to what extent relevant information is available within the municipalities in question. In general however, it is obvious that the local information, with few exceptions, is inadequate both in terms of quantity and quality.

Data from national and regional sources are generally sampled using uniform methods, and are thus well suited for use as baseline information. Some information, e.g. fish sampling data, might be scarce or even absent in some of the municipalities.

Below, the most relevant national and regional sources are described.

The National Board of Fisheries (Fiskeriverket)

The environmental unit at the Board's fresh water laboratory has been carrying out fish sampling in Swedish lakes since 1983, monitoring the change over time in Swedish fish populations. The programme is financed by SNV, and is part of the national environmental monitoring programme. All sampling efforts carried out within the frameworks of both the national and regional monitoring programmes as well as the liming monitoring programme, are to follow the sampling standards given in the Handbook for Environmental Monitoring /Naturvårdsverket, 1996/. The data from the sampling is available via the Internet /Elfiskeregistret, 2000 www/.

The Board is the data host also for the regional programmes, which means that the results from the sampling carried out by the County Administrative Boards are also available in the same database. The positions of the sampled lakes are given according

to the Swedish national grid (Rikets Nät). Several of the lakes included in the monitoring programmes are situated within the municipalities in question.

The Fresh Water Laboratory is also a host for results from all the electric fishing efforts that are carried out in Sweden, as responsible for Elfiskeregistret. The frequency of reporting from the samplers is, however, much lower than is the case for the net sampling. Some additional information is, therefore, possibly available locally, e.g. from the County Administrative Boards.

The temporal resolution varies, everything from a single effort to a time series of several years is represented in both the net and electric fishing statistics.

The Board of Fisheries is also responsible for logbook statistics from the professional fishery (licensed fishermen).

The Board of Fisheries also carries out, in co-operation with Statistics Sweden, national surveys on the extent of leisure fishing, approximately once every ten years.

The Swedish Environmental Protection Agency (SNV)

SNV initiates and orders national and regional fish stock monitoring programmes. One of the most important ones being the liming impact monitoring. SNV is also responsible for the design of standardised sampling methods (net fishing).

Statistics Sweden (SCB)

SCB used to be responsible for producing a yearly review of the extent of the professional fishery (catches, number of fishing boats etc.). The Board of Fisheries took over this responsibility in 1996.

The County Administrative Boards

The county boards carry out regional fish (ecological) surveys, both on behalf of SNV or on their own initiative. The type of surveys varies, and includes standardised net sampling, electric fishing, inventories of migration obstacles, spawning ground mapping (rheophilic fish) etc. The sampling frequency also varies, between single sampling efforts and annual monitoring activities.

The county boards keep records of the number of licensed professional fishermen in their respective counties. They are also the authority in charge for releasing permits for various forms of aquaculture businesses (e.g. fish and crayfish farming), as for supervising the fish management associations.

Spatial coverage and resolution

The county of Kalmar

The county administrative board

The board's unit for agriculture and fishery in Kalmar keeps general information in "Fiskefakta Kalmar län". The information deals mainly with data on professional fishery, e.g. the number of fishermen, type of fishery, fishing-fleet, harbours and information on aquaculture. The information is regularly updated.

Positions are given according to co-ordinates, but the use of Geographic Information System (GIS) is increasing also in this field.

All fish management associations are registered at the board. The associations are obliged to inform the board on changes within the associations, such as updates on activity plans, management replacements etc.

The board's local office in Västervik, carries out (since 1986) annual fish sampling in six streams in the county of Kalmar at so called environmental monitoring stations. The purpose of this is to monitor changes in fish stocks, with focus on anadromous trout. Positions are given according to co-ordinates. One of these streams (Sällevadsån) runs through the municipality of Hultsfred /Åkerman, 1998/. Moreover, some scattered follow-up studies on primarily trout and crayfish stocks are carried out.

The board's unit for environmental conservation have sampling data from a number of lakes (mainly limed lakes), where they carry out net fishing on behalf of SNV. Positions are given according to co-ordinates. The sampling is carried out in accordance with the standardised fish sampling methods developed by SNV and the National Board of Fisheries /Molander, Appelberg, 1999, pers. comm./. These sampling efforts are performed according to a rolling schedule within the county. In 1998, 14 lakes in 3 municipalities (Nybro, Kalmar and Högsby) were sampled.

In total, there are data from 139 sampled lakes from 201 efforts. Some of these lakes are situated within the municipalities in question.

Hultsfred

A report /Holm, 1995/ comprises 52 lakes and 11 watercourses within the municipality. The material is presently being updated, and will comprise approximately 60–70 lakes. The new report is expected to be completed by November 1999. The material will be available via Internet at a later date. Both the report and the raw data will be accessible at the municipality's offices.

Oskarshamn

Information concerning fish/fishery is nearly non-existing at the local level. The municipality does not carry out any studies. They have some information on existing fish farms and they are aware of the sport-fishing associations and fish-management associations.

Fish-management associations/Sport-fishing associations

Information on the full extent of sport fishing is possible to derive from the county administrative board's register on sport-fishing associations and fish-management associations. From these associations one can obtain information on the number of members, number of sold fishing licenses in different categories etc.

Individual associations sometimes also keep statistics on catches. This information is generally defective and with several sources of error.

The county of Södermanland

Professional fishery

In total, there are app. 20 licensed professional fisherman in the county. Besides the fishery in the lakes Mälaren and Hjälmaren, there are also some fishermen that fish both along the coastline and in smaller lakes. Some of these smaller lakes are within the borders of the municipality of Nyköping. The fishing for crayfish is increasing, both in terms of value and range. This is particularly true for the catchment of Nyköpingsån that, to a large extent, is situated within the municipality of Nyköping.

Sport fishing

The county boards have full knowledge about the fish-management associations. There are also an unknown number of sport-fishing associations. One of the most active ones being Nyköpings and Oxelösunds sport-fishing association, that runs a continuos monitoring of ascending salmon and sea trout in Nyköpingsån.

Biological fish studies:

The county's fish studies are in accordance with the guidelines given by SNV and the National Board of Fisheries. The latest sampling effort of any magnitude was carried out in 1997 /Nilsson, 1999, pers. comm./.

The municipality has performed studies on the mercury content in fish during 1998 /Albing, 1999, pers. comm./.

The county of Uppsala

Tierp

The municipality does not carry out any fish surveys on their own. But on the initiative of the municipalities in the county, the foundation Upplandsstiftelsen performs various types of surveys, e.g. net fishing and electric fishing in the lakes and watercourses of the county as well as an inventory of small coast-bound streams with focus on fish migration /e.g. Nyberg, 1999/.

The local government keeps track of all the fish-management associations within the municipality.

Älvkarleby

Nedre Dalälven is the most important area, with species like salmon, sea trout and lamprey. The sport fishing activities in the area are of a very significant magnitude, and there are data available on both licence sales and catches of fish /Hägglund, 1999, pers. comm./.

Östhammar

No particular surveys besides the ones in the regional programmes.

The county administrative board of Uppsala

In the county, there are 5–6 active professional freshwater fishermen, all fishing on lake Mälaren, which means that there is no professional fishery in the municipalities in question. In total, there are app. 20 fish-management association, of which several are active in the three municipalities. The board has all necessary data on these associations.

The most important areas for sport fishing are found within the catchment of river Dalälven. A major study on the extent of sport fishing in that area was performed in the middle of the 1980s /Hägglund, 1999, pers. comm./.

Regarding fish sampling by means of net fishing, the report by Upplandsstiftelsen /Nyberg, 1999/ is referred to as the best all-encompassing source of data /Lagström, Amneus, 1999, pers. comm./. It gives summarised data from the results of net fishing in 83 lakes in the county.

The board of fisheries local office in Härnösand, as part of a national survey, has performed surveys including i.e. electric fishing of coastal streams /Appelberg, Hägglund, 1999, pers. comm./.

Besides the material most likely available at the former inspectors offices in Gävle and Härnösand, there are also some surveys performed by the University of Uppsala /Hägglund, 1999, pers. comm./.

Temporal resolution

See above.

Statistical properties

See above.

Methods/models used for existing data

See above and below.

2.1.2 Methods for data collection

The demand for standardised methods is high with regard to the collection and analysis of data from net fishing and electric fishing. Biomass (weight), number of individuals/ area, weight/area and catch per effort are some examples of frequently used units of measurements in fish sampling.

Stock estimations, particularly based on net fishing in lakes, generally require a great amount of sampling efforts. The results are affected by a number of factors, such as in-between and within-year variations, seasonal and daily variations (in turn depending on e.g. temperature and light conditions), food access, age distribution and migratory patterns etc. A suitable method for stock estimations in lakes is therefore some kind of acoustic method (echo sounding or sonar) in combination with gill-net fishing.

Suitable methodology descriptions can be found in the following publications:

- Degerman and Nyberg /1988/.
- Filipsson /1972/.
- Naturvårdverket /1996/.
- Naturvårdsverket /1999/.
- Degerman and Sers /1999/.

Background data needs

Gill-net fish sampling, aiming at estimations of relative numbers and total weight of fish in a lake requires knowledge of the area as well as the depth conditions of the lake.

Electric fishing in running waters, aiming at density (stock) estimations of various fish species within an entire, or parts of, a catchment, requires knowledge of the size of the upstream catchment, typical flow patterns, head, occurrence of migration obstacles, occurrence and distribution of different fish habitats and, of course, also knowledge about the habitat preferences of different fish species.

The demand for data accuracy depends on the purpose of the study. If the purpose is to study the occurrence of various species and to get a reasonably good picture of the inter-species distribution, then the precision can be set at a fairly low level. If, on the other hand, the aim is to e.g. study how different activities in the surroundings affect the fish populations' structure and constitution, the demand for accuracy is higher.

Time schedule

Hydro-acoustic surveys with complementary gill-net sampling should be carried out in one sequence /Hansson, 1999, pers. comm./. Net sampling should be carried out during the time of the year when the likelihood of any fish species being in a breeding phase is as small as possible. In order to avoid temperature dependent effects, the surface water temperature should be at least 15^{o} C (in the south and middle parts of Sweden) /Naturvårdsverket, 1996/.

The most suitable time for carrying out electric fishing in running waters depends on the purpose of the survey. Important factors here are the time of year and the water temperature. For surveying the occurrence of different species, late summer is the best time of year /Degerman and Sers, 1999/. If the purpose is to estimate densities of salmonoid juveniles, then August-September is an appropriate time of year, as the water temperature gets lower /Degerman and Sers, 1999/.

Potential resources

The National Board of Fisheries (electric fishing, net sampling).

SwedPower (stream habitat surveys, electric fishing, net sampling, collection and assessments of catch statistics etc.)

Hydro-acoustic surveys can be performed by AMFAB (Akvatisk Miljöforskning AB). AMFAB has a great deal of experience of hydro-acoustic surveys with a very advanced sonar technique.

Uncertainty – Risks

Hydro-acoustic surveys in lakes, for the estimation of fish populations, require a certain depth. In shallow lakes, the precision suffers notably.

Biological fish surveys such as net sampling and electric fishing often reveal substantial in-between year and seasonal variations. In lakes, the variations during a 24-hour period can also be substantial and must be accounted for in net sampling and hydro-acoustic surveys.

The demands for high quality surveys can be fulfilled by engaging firms with staff trained for, and with a high degree of experience of, the different survey methods.

Effects on environment

Standardised net sampling always causes the death of the fish caught in the net. During normal circumstances, this type of sampling does not affect the fish stock in general. In some extreme cases, e.g. in lakes where fish are being released (e.g. put-and-take lakes), net sampling could negatively affect the desired results of the releases.

With the exception of fish being collected for further analyses, electric fishing, properly performed, does not affect fish stocks in running waters. The shock treatment normally does not cause the fish any harm.

2.1.3 Costs

Existing data

The time needed for collecting and analysing **existing** data can be estimated to app. 2,5 person-days, or app. 13 000 SEK per site.

Data collection from lakes for fish stock estimations

A feasible way of performing this type of study is a combination of gill-net sampling and hydro-acoustic surveys.

The time needed for gill net sampling is dependent on the lake's size and abundance of fish. In oligotrophic lakes, a 24-hour period would normally be needed for two fishermen to sample with 8 bottom nets and 2 floating nets and to analyse and register the catches. In eutrophic lakes, the number of net effort per night should be decreased, which means that the total time needed will increase /Naturvårdsverket, 1996/. The time needed for a hydro-acoustic study varies, depending on the size and depth conditions of the lake.

The cost estimates below are based on the following assumption:

A lake with the size of 100 hectares (littoral and pelagic zone) is surveyed by means of gill-net sampling and hydro-acoustic survey.

Hydro-acoustic survey: Including data processing, equipment rental and reporting the cost will be app. 50 000 SEK.

Gill-net sampling: Including sampling at 12 stations (8 littoral and 4 pelagic stations) during 4 days (2 people), the cost will be app. 110 000 SEK.

Data collection for estimation of the extent of fish in a lake

The study can be performed as an enquiry, either in the field or by mail. The cheapest alternative is a mail enquiry, and that can be estimated to app. 30 000 SEK per site (lake).

Electric fishing surveys (running waters)

The cost for a typical quantitative survey (at least 3 efforts per site) at 3 sites in a stream is app. 45 000 SEK.

Stream habitat survey

The stream habitat survey is an important basis for the electric fishing study. The time needed depends on the size of the stream and the demand for accuracy. An estimated cost for a detailed survey would be app. 55 000 SEK per 10 km of stream length.

Material, special resources

Lake surveys for estimation of fish stocks:

- Sonar equipment, the advanced type needed for this purpose costs app. 500 000 SEK (this equipment is available for rental).
- Bottom gill nets (e.g. of the type “Norden”).
- Floating (pelagic) gill nets.
- Boat, boat engine and trailer for sonar and net sampling surveys.

Stream surveys:

- Equipment for electric fishing, e.g. Biowave II or LUGAB.
- Flow meter, equipment for area calculations etc.

Time requirements

See above.

2.1.4 Conclusions

With the exception of data on professional fishery and aquaculture, it is probable that the data at hand is insufficient, both with regards to quality and quantity. The need for data and its precision must be determined. This should be done based on both the type of influence expected from the deep-level repository, and on the type of environments (lakes, streams) that exist within the affected area.

3 Variable group Physical Geography

3.1 Landscape

The landscape is a natural and cultural inheritance, which is appreciated for its aesthetic values as well as its important contribution to regional identity and sense of place /Goodey, 1995/. Most people know what they like when it comes to viewing the landscape and at the same time landscape impacts are possibly the most subjective impacts addressed in an EIA. To make the assessment as objective as possible it is recommended to, in addition to a description of the impact, construct a picture of the project appearance in the proposed location.

Impact on landscape is determined through two entities, first the exposure of the project in question and second the degree in which the project contrasts with the surroundings. The exposure is dependent on the topography, major ridgelines and direction of open views. The contrast on the other hand is the result of land-cover, land use and the presence of designated features of any landscape, heritage and other significant designations for the area /Goodey, 1995/.

A picture of the impact can be created with the aid of GIS analyses of the topography and photo mosaics of the object as seen from different viewpoints.

3.1.1 Existing data

Existing data do mainly consist of general descriptions of the landscape from which further conclusion must be drawn, such as;

Land form setting – for an initial analysis, **topographic maps** can be used to identify the proposed location and the visual context within which the project is to be located (e.g. topography, major ridgelines, and direction of open views). These exist for all investigated areas and can be ordered from Lantmäteriet.

Land-cover setting and land use are available from topographic maps and **aerial photographs**. Aerial photos are available for large parts of Sweden and can be ordered from Lantmäteriet.

Protected areas and features that establish the character of the landscape and cultural heritage are defined in general plans (översiktsplaner) and nature conservation programmes (naturvårdsprogram). The former can be ordered from the local authorities (municipalities) and the latter from the county administrative boards.

An intervisibility analysis can be done using maps indicating land use (topographic map 1:50 000) and an **elevation database** and drawings of the project. Analyses can be made using a GIS software like Arc View Spatial Analyst. Elevation data can be obtained from Lantmäteriet.

3.1.2 Methods for data collection

Besides the data mentioned above, field observations and photography are necessary to get a correct picture of the impacts. Using photo mosaics it is possible to show the depth and character of views around the proposed site. For this purpose, it is necessary to obtain high quality photographs from clearly defined viewpoints and CAD drawings of the specific project, these should preferably be 3D drawings (can be added afterwards).

Depending on the proposed location, it might be desirable to use photos from different seasons as well as photos taken from a high elevation such as a helicopter.

A photo mosaic is then created using advanced picture editing software like Adobe Photoshop.

Background data needs

Background data needs are mainly elevation data, digital map materials and high-quality photos of the project's impact area.

Time schedule

The impact on the landscape can be analysed as soon as the proposed location and design of the project is clear. The work should be started at least a year ahead of expected finalisation date if the location suggests a need for impact assessments for different seasons. The time needs is depending on the required quality of the photo mosaics.

Potential Resources

The project should be assigned to someone with experience of these types of questions and knowledge of GIS and photo mosaics. SwedPower complies with these requirements and has the necessary experience in this field.

Uncertainty – Risks

It is of great importance that the photo mosaics are conducted with accuracy to ensure a correct scaling of the fitted objects.

Effects on Environment

None.

3.1.3 Costs

Material, special resources

Maps, aerial photos and an elevation database can be ordered from Lantmäteriet at an approximate cost of 30 000 – 40 000 SEK per topographic map sheet (25 x 25 km).

Time requirements

The time needed for the assessment is mainly dependent on the location of the project, the required number and quality of the photo mosaics. An estimation would be in the range of 150–250 person-hours per site.

3.1.4 Conclusions

Assessment of impacts on landscape is a very subjective thing. It is because of this crucial to collect and present as objective material as possible, such as intervisibility analysis and photomontages.

Landscape impacts is a variable of importance for the EIA and background data is available for this assessment when the specific proposed location and design of the project is fully known. It is however difficult to accurately estimate the required time and cost before the exact location and design have been defined.

4 Variable group Biota

The variable group biota is a complex group, with its full context of “all living organisms in a given space”. A complete knowledge of this full meaning is impossible, but also unnecessary, to reach in order to establish a useful description of the areas concerned. Instead, a limited set of variables that together enable an understanding of the ecology of the area concerned is desirable.

In this work, the occurrence of species and habitat types in a general context, together with particular emphasis on key biotopes and red-listed species is determined to be the proper set of variables.

Thus, the variables described below are:

Vegetation types, key biotopes, species, red-listed species, floral and faunal biomass. Marine environments are excluded from our scope.

4.1 Regional and local sources

Some information on the variables in the group biota is available on a regional and local level, i.e. at the county administrative boards and municipalities. Here, relevant information sources existing at these authorities are reviewed. However, these regional and local data are generally scattered and of various quality and relevance. This means that the comparability will be low, and some of the potential sites lack coverage. In the text hereafter, focus will be kept on national data sources. In most cases, these have the advantage of being based on standardised methods and thus giving comparable and transparent data.

4.1.1 The county administrative boards

Kalmar

The board in Kalmar possesses a relatively good coverage in GIS format for the issues concerned. The GIS system used is ArcInfo/ArcView /Forslund, 1999, pers. comm./. GIS layers are available for the nature conservation programme, the ancient meadows and pastures survey, the key biotope survey, the wetland survey and some additional local and regional surveys with focus on botany /Forslund, 1999, pers. comm./. On request, a CD with all available GIS information can be delivered, at a cost of app. 500–1 000 SEK.

Besides this, the board has published several surveys, and a list of these publications is available on the board’s website /Länsstyrelsen Kalmar län, 1999 and 2000 www/.

Uppsala

Some surveys of nature conservation issues have been performed for some areas of the county, e.g. the municipality of Östhammar. These surveys are, however, of varying age and scope /Hjälm, 1999, pers. comm./. Some information has been implemented with the aid of GIS, such as e.g. the areas of national interest within the county /Karlsson L, 1999, pers. comm./.

Södermanland

Some information is available in GIS format /Karlsson S, 1999, pers. comm./. Examples of this are the areas of national interest, ancient meadows and pastures survey etc. They also have results from the survey of key habitats performed by the National board of forestry (Skogsstyrelsen) in their GIS system.

4.1.2 The municipalities

Most of the staff contacted at the municipal authorities refers to material possibly available at the respective county administrative boards. The material available on the municipal level is often very scattered and it is therefore not possible to decide their relevance until the survey sites have been selected.

Oskarshamn

Nothing is available in GIS format. Some surveys have been performed in various parts of the municipality /Johansson, 1999, pers. comm./, but the only one with any relevance is the vascular plant survey by Rühling /1997/.

Hultsfred

Nothing is available in GIS format. Scattered surveys have been performed in various parts of the municipality, with different scope and focus and by using different methods /Helgée, 1999, pers. comm./. No all-encompassing surveys have been carried out. Some studies of the flora and fauna in running waters could be relevant (see also variable Fishery 2.1).

Nyköping

GIS is being introduced at the authority /Eriksson, 1999, pers. comm./. So far, the only thing yet implemented in GIS is the ancient meadows and pastures survey. Some surveys have been carried out during the development of the municipality's nature conservation plan.

Östhammar

No relevant information is available /Jivander, 1999, pers. comm./.

Älvkarleby

In their GIS (MapInfo), layers with findings of red-listed species are available. The information is free of charge /Geimar, 1999, pers. comm./.

Tierp

The municipal authority has stored data from the database at ArtDatabanken in their own GIS /Amnéus, 1999, pers. comm./. The information is classified, but is available from ArtDatabanken. No other relevant data is available.

4.2 Vegetation types

Vegetation types are important features that characterise the landscape. They provide habitat for the variety of species that inhabit them, that in turn are a part of the landscape characteristics. Vegetation types are interesting also in a monitoring context, since they are, in contrast to most species, relatively easy to identify and thus to follow in a long term perspective.

4.2.1 Existing data

Data concerning vegetation types can be found in several different sources (databases, written sources etc.) and in different resolutions. Below, the most relevant and standardised ones are described.

1. Swedish CORINE Land Cover is a part of the overall mapping scheme for Sweden /Rymdbolaget, 1999/. The chief products will be two national databases – one that meets European requirements (CORINE Land Cover), the other a more detailed national database, Swedish Land Cover (SLD). Since the final products are digital, they will allow flexibility for further applications in digital analyses, or as material for printed maps, for example.

   The pilot production will be in progress up to 1999, after which the remainder of the production will be completed. Ready-to-use data is expected to be available in 2002.

2. The Swedish Terrain Type Classification (TTC) is a digital mapping project based on satellite imagery. A total of 900 map sheets have been produced, each covering an area of 25 by 25 kilometres, in all about 500 000 km^2 /Andersson C, 1999, pers. comm./. To obtain complete coverage of Sweden, 46 Landsat and 12 Spot scenes have been utilised.

   The TTC is stored as raster data organised in 25 by 25 km map sheets ready to be imported to e.g. ArcView or any other GIS.

3. The Swedish National Forest Inventory (Riksskogstaxeringen). The sample plots are laid out objectively and systematically, covering the whole country every year, except for the high mountain area in the north-west. Thus, forming a good statistical representation of Sweden, the plots enable large-scale site mapping and environmental monitoring. Data is available from the Internet /Riksskogstaxeringen, 2000, www/.

4. The National Survey of Forest Soils and Vegetation (SK) is a long-term inventory of permanent sample plots of the Swedish National Forest Inventory.

During the period 1923–1982 all plots in the survey were temporary. However, in 1983 the design was changed and the survey began to use both temporary and permanent plots. This meant that it became an even better tool for environmental monitoring, since regular re-measurements of the same plots are superior for the detection of changes over time. Geographically arranged data can be obtained directly from a web-site at SLU Markinfo /2000, www/. The data is, however, limited in its resolution. But from the same source, it is also possible to get basic data /Lundin, 1999, pers. comm./. Then it is possible to view data per sampling plot /Carlsson, 1999, pers. comm./.

Besides these nationally nearly all-encompassing data sources, there are some data on the local level, e.g. at the municipal offices and the county administrative boards.

Spatial coverage and resolution

1. The Swedish Land Cover (SLD) database will comprise 52 vegetation and land use classes. The resolution will be limited to between 1 to 5 hectares. The ambition is to use 1 hectare for the types that can be obtained through computerised characterisation (mainly the different forest and mire types).

   It will, however, be possible to get information with a better resolution than above. One (future) option is to get information covering squares with the size of 25 x 25 metres (the original, un-aggregated pixel size). This will, however, increase the uncertainty of land use class characterisation /Lundgren, 1999, pers. comm./.

   It is possible to, on request, obtain the same kind of information prior to year 2002. The data can be delivered in both raster or vector form, depending on the format needed /Lundgren, 1999, pers. comm./.

2. The Swedish TTC is presented in 13 classes with a resolution of 25 by 25-metre pixels. Before the classification process the satellite images are geometrically precision corrected to correspond to the Swedish National Grid. Arial photos are used for reference and for verification of the classification results. The latest update for parts of the TTC was produced by data from summer 1999.

3. The Swedish NFI is based on random sampling and only covers forested land. A sample of the trees, of the ground vegetation, etc, are randomly selected and used for estimating the total volume of all trees, the total area of land covered with a certain vegetation and so on.

   The inventory is implemented within defined circular **plots**, with the radius of 7–10 metres. The plots are clustered into **tracts**. These are square or rectangular in shape and vary in size between different parts of the country.

   The tracts are **systematically distributed** over the whole of Sweden. The distance between them is shorter in southern than in northern Sweden. The Swedish National Forest Inventory uses two kinds of tracts. One is temporary and the other permanent. The temporary tract is only surveyed once, where as a permanent tract is resurveyed regularly

   Because the Swedish NFI is carried out as random sampling, the precision of the estimated figures can be estimated.

The density of the tracts/plots is adjusted, by using information from a 5 year period, to give good precision for estimates at a county level.

4. The National Survey of Forest Soils and Vegetation (SK), is represented by sample sites in the administrative counties (län) as follows (surveys 1983–87 and 1993–98):

County	No. of sites (83–87)	No. of sites (93–98)
Uppsala	453	256
Södermanland	434	258
Kalmar	855	514

The resolution in SK will not allow analyses on smaller areas /Lundin, 1999, pers. comm./. The county level is, most likely, the smallest possible unit. However, if a sample site is situated within the area in concern, it will be possible to get detailed data on the vegetation within this plot (normally with an area of 314 m²).

Temporal resolution

1. The SLD database is scheduled to be updated every 5–10 years. On request it is possible to get new data with a higher frequency /Lundgren, 1999, pers. comm./.

2. The TTC is being regularly updated, and parts of Sweden were recently updated using satellite data from the summer of 1999. Previous data are from two periods, 1988–90 and 1994–98, respectively /Andersson C, 1999, pers. comm./.

3. The NFI is carried out in 10-year cycles. The statistic design is the same during each cycle, whereas the studied parameters can be modified in the middle of each cycle, i.e. every 5 years.

4. During the period 1983–1987 about 23 500 permanent plots were established. In 1993 the remeasurements started, and according to the plan, all 23 500 plots will be remeasured in 2002.

Statistical properties

Data is available for the whole of Sweden (except for the mountain regions), with the exception of SLD, that will not be carried out in full until 2002.

Methods/models used for existing data

1. The SLD uses satellite data as the main source of information. This data is combined with several other digital and analogue sources of information in order to establish map layers containing the information needed to produce relevant maps.

2. The TTC uses satellite data for presenting and analysing landscape features.

3. The National Forest Inventory is carried out as random sampling of a nation-wide network of sample plots (see further above).

4. The relevant steps included in SK are, in brief:

   - A general site description of the area closely surrounding the plot, including e.g. general hydrological conditions, typical soil depth etc.
   - A description of soil types and soil horizons.
   - A description of the vegetation, with emphasis on non-timber aspects.
   - Inventory of pendulous lichens and algal growth on spruce needles.

After checking for errors and adding data from chemical analyses, all data are put in SK-BAS, the general database of the SK project. There are e.g. data of the species composition of the bottom- and field-layers. The variables can easily be combined with the forest inventory data of forest stands from the same plots.

4.2.2 Methods for data collection

In the early parts of the project (i.e. the site selection), we feel that a practical way of dealing with this variable is to use the satellite imagery as described above (SLD). This will give a digital map with an acceptable degree of resolution and at a reasonable cost.

When the survey sites are finally selected the need for an increased resolution will rise. This need can be met by a combination of aerial photo interpretation and field visits of the smaller areas that should be studied, e. g 2 x 2 km.

The potential resolution is depending on the quality of the available aerial photographs, which means that the need for additional field visits will increase if only panchromatic photographs are available, while it can be held on a moderate level if larger-scale (e.g. 1:30 000) infrared pictures are at hand.

We suggest that the vegetation types should be classified according to the system given in Vegetation types in the Nordic Countries /Påhlsson (ed.), 1994/.

Background data needs

The most important background data is the availability of aerial photographs. If possible, these should be taken close in time to the site surveys, thus enabling elimination of non-project disturbances, and during early summer in order to enhance the possibility to sort the different vegetation types in a satisfying manner /Skogsstyrelsen, 1993/.

Time schedule

The satellite image interpretation in accordance with SLD (above) could be done at the time found most appropriate, since the necessary input data (satellite images) is available at all times.

The interpretation of infrared aerial pictures, in combination with in-situ studies, must be carried out prior to the site surveys and the fieldwork preferably during early to mid summer.

Potential resources

It is the authors' opinion that it is convenient to have one consultant that is responsible for both gathering the data for the larger area, and for accomplishing the larger-scale data baseline (interpretation of aerial photographs and field work). SwedPower has the contacts and internal competence for both assignments. Other consultant firms may also have the appropriate staff and knowledge to carry out this work.

Uncertainty – Risks

Complementary field visits will be necessary to both ensure the reliability of the data set, as well as to choose monitoring sites.

Effects on environment

None.

4.2.3 Costs

Existing data

1. A premature (prior to the actual release) SLD map sheet of 25 x 25 km, will cost app. 30 000 SEK /Lundgren, 1999, pers. comm./. This sum implies that no additional data collection will be necessary, i.e. the data available at The Swedish Space Corporation Group will be used.

   After 2003, pilot data will be available at the cost of app. 2 500 SEK per SLD map sheet /Lundgren, 1999, pers. comm./.

2. The TTC is available for immediate delivery on CD ready for use in ArcView. The cost (September, 1999) per map sheet covering 25 x 25 km is listed below.

Fixed fee per order, irrespective of number of map sheet:	3 000 SEK
Price per map sheet pixel size 50 metres:	500 SEK
Price per map sheet pixel size 25 metres:	1 100 SEK

3. These data are free of charge and available via the Internet.

4. These data are free of charge and available via the Internet.

Additional surveys

The cost for interpretation of aerial photographs and complementary field visits is difficult to define at this time. The size and complexity of the sites that are to be studied is the key factor determining the time needed for the work and thus the costs. Given an area of 2 x 2 km, an early estimation would be 2 person-days of work per site for interpretation, map production and area calculation. An additional 2 person-days for field visits for correlation and quality checks per site is an approximate estimation. This would lead to a cost of app. 25 000 SEK per site, excluding travel costs. Infrared aerial photographs can be bought from Metria, at a cost of 373 SEK/picture /Berglund, 1999, pers. comm./.

Material, special resources

We suggest the GIS software ArcView for the handling of information.

Time requirements

See above.

4.2.4 Conclusions

Information on vegetation types is, at the local level, often absent. Where present, it is very fragmented and sometimes quite outdated. Before the survey sites are finally determined, it is not feasible to state the amount and quality of existing data at this level. On a national level however, there are some interesting data sources possible to use in this matter. The advantage with this type of data is that the methods used will give information that is comparable for all potential sites.

Therefore, we suggest the following procedure:

- For the initial vegetation type study, satellite image interpretation in accordance with SLD (above) will be sufficient.
- For the better resolution, interpretation of infrared aerial photos, in combination with in-situ studies, is the best way of reaching the high level of reliability needed for establishing the fine scale baseline.

4.3 Key biotopes

Key biotopes are generally defined as areas, often small ones, that harbour, or have the potential to harbour, red-listed species. One example of this is the system of woodland key habitats used by Skogsstyrelsen (National Board of Forestry) in Sweden /Skogs-styrelsen, 1994/.

4.3.1 Existing data

Three nation-wide sources with applicable information are available:

1. The National Board of Forestry has initiated/conducted national inventories of woodland with regards to key biotopes. These inventories embrace *woodland key habitats*, *swamp forests* and *nature conservation areas*, the latter being areas with certain values but not fully reaching the level of key habitats.

2. The National Wetland Inventory. In the early 1980s, a national wetland survey was initiated by SNV. The wetlands provide habitat for a variety of species, and they often harbour high biological values.

3. The National Inventory of Ancient Meadows and Pastures began in 1987, initiated by the SNV. Results from the inventory are published both by SNV and by the respective county board. The meadows and pastures given high values in this inventory can be considered as the key biotopes in the agricultural landscape.

Spatial coverage and resolution

1. The data resulting from the inventories of woodland key habitats, swamp forests and conservation areas made by Skogsstyrelsen, is available at their homepage /Skogsstyrelsen, 2000, www/. By selecting an area, e.g. a community, it is possible to view a map with all of these areas plotted. By pointing at one area, you get an information sheet of the area, giving detailed attribute information of the site, such as:

   - Type of biotope.
   - Size.
   - Co-ordinates and other information on location.
   - Date of inventory.
   - Key elements (including frequency).

   The geographical data from the inventories is stored as polygons in vector shape files, according to the grid Rikets Nät. The attribute information is stored in an Access data base. This data is possible to request from the local offices at prime cost, i. e. the cost of assembling the data, but no charge for the material itself. A list of these offices are found at the homepage of Skogsstyrelsen /2000, www/. From these offices, it is also possible to request information from defined (smaller) areas.

   Additional attribute information (such as registered species) can be also requested from the local offices in the respective region.

   The woodland key habitat and conservation area surveys are nation-wide, except for non-private woodland. The swamp forest survey included the whole nation except for Norrbotten. The forestry companies, that were not included in the national survey, are making the same kind of surveys on their corporate lands. This work is scheduled to be ready in 2003 /Grönwall, 1999, pers. comm./. The plan is, thereafter, to merge the results from both the national survey and the corporate surveys into one database, covering all forested land in the country /Grönwall, 1999, pers. comm./.

2. The wetland survey has now been carried out over the entire country, except for the mountain region and Norrbotten, where it still is not finished. In the southern part of Sweden, all wetlands larger than 10 hectares were studied. In the counties of Blekinge and Malmöhus the limit was set to 5 hectares, whereas on the islands of Öland and Gotland it was set at 2 hectares.

   All in all, the survey embraces more than 26 000 wetland objects, of which more than 4 000 have been surveyed in field. Data on the wetlands are put in a database at the SNV. The respective administrative boards also publish detailed survey results.

3. The Ancient Meadows and Pastures survey has now been conducted over the entire country. No sites smaller than 1 hectare are included in the survey. Results are possible to obtain from the respective county administrative board.

Temporal resolution

1. The inventories made by Skogsstyrelsen were conducted during the years 1993–98. The database is, however, continuously being updated with new data on existing biotopes but also with new biotopes, as these are discovered /Grönwall, 1999, pers. comm./.

2. The wetland survey began in the early 1980s and is still going on. No specific update is scheduled.

3. The National Inventory of Ancient Meadows and Pastures was conducted between 1987–1990. The county administrative boards are carrying out various monitoring activities, which means that up-to-date data is possible to obtain locally.

Statistical properties

All of the above surveys are nation wide, which means that data is available for all potential sites. The exception is the key habitat survey, where data is lacking for corporate forests. The only way to address this problem, if it occurs, is to obtain the information needed from the forestry companies, or to make complementary surveys according to the methodology used by Skogsstyrelsen (see above). There are no feasible ways of applying data from one area to another.

Methods/models used for existing data

1. The swamp forest survey was conducted in two steps, remote sensing and field survey. The remote sensing was carried out by interpretation of infrared aerial photographs. A minor fraction of the sites, app. 5–10%, mainly those with a high value, were visited and studied on location.

   The key habitat survey was also conducted in two steps, remote sensing and field survey. All sites defined as key habitats were visited in field. The criteria used by the field personnel in order to decide whether or not an area qualifies for being a key habitat is threefold: the forest history, population structure (trees) and the species content.

   In the search for key habitats, areas with high natural values but lacking some of the characteristics necessary for reaching key habitat status, have been found. These sites are called “nature conservation areas” (objekt med naturvärden eller naturvär-

desobjekt). They can be described as future key habitats, i.e. biotopes that have the potential to, in maybe 10–30 years time, evolve into key habitats.

2. The wetland survey was conducted according to the method presented in SNV's report PM1680 /Göransson et al, 1983/. Out of more than 26 000 wetlands, about 4 000 were visited on site.

3. The methodology used in the inventory of ancient meadows and pastures is given in SNV´s report "Inventering av ängs- och hagmarker" /SNV, 1987/. In brief, the method can be described as a four-step process; preparatory work (including interpretation of aerial photographs), field survey, site evaluation and reporting.

4.3.2 Methods for data collection

Background data needs

Digital maps are needed, i.e. digital geographical data layers, e.g. economic maps, that additional information can be plotted on.

Time schedule

Since the data already exists, the collection and aggregation of it into a GIS can be carried out at any suitable time.

Potential resources

The collection of relevant data and construction of a GIS database can be made by SwedPower, or other consulting agencies.

Effects on environment

None.

4.3.3 Costs

1. The data can be requested from the local offices at prime cost, i. e. the cost of assembling the data, but no charge for the material itself. As an example, generating shape files and attribute data from the municipality of Oskarshamn will take 2–3 hours of work at the cost of 425 SEK/hour /Grönwall, 1999, pers. comm./. The time needed for this varies; depending on the workload, but somewhere between a few days to 1–3 weeks is probably the time span needed /Grönwall, 1999, pers. comm./.

2. The data owner, SNV, is presently selecting a data host for the wetland inventory database /Abenius, 1999, pers. comm./. According to the plan, the data will be accessible at the new host sometime in 2000. Prior to that, county-wise data can be provided from the respective county administrative board /Abenius, 1999, pers. comm./.

3. Data can be collected either from the reports published by the respective county administrative board, or from the GIS applications at the same authorities.

Material, special resources

We suggest the GIS software ArcView for handling of the information.

Time requirements

An estimation is that the collection of relevant data and the construction of a GIS database would take app. 150–250 person-hours of work.

4.3.4 Conclusions

The information in the different national surveys mentioned above is sufficient in all respects but one, large-scale commercial forest land. If such forests are situated in the selected sites, information should be possible to attain from the respective forestry companies /Grönwall, 1999, pers. comm./. The other key biotope information, i.e. data on valuable wetlands, meadows and pastures is definitely of the desired resolution and quality. This variable can thus be regarded as sufficiently covered in all relevant aspects.

4.4 Biomass (flora)

This variable aims at describing where or how to obtain relevant information on vegetation biomass on a regional scale, with emphasis on mass/area-indexes and production.

4.4.1 Existing data

The information can be put into four categories, depending on the land use/vegetation type:

1. Forests

   Information on forests in general and wood yield, growth and supply in particular, is available via the studies undertaken by the Swedish National Forest Inventory (NFI) (see also section 4.2) Data from NFI is available on the internet /Riksskogstaxeringen, 2000, www/. Data on carbon content in different forest soils can be obtained from the SLU database Markinfo /2000, www/.

2. Cultivated lands

   Statistics Sweden (SCB) publishes reports on standard yields from the agricultural lands in the country. Sweden is divided into 104 yield districts, and calculated yield data is available from all these districts. On the homepage of Statistics Sweden /2000, www/, it is possible to get access to their database on agriculture. The data available from this source is compiled on a county level, and contains data on harvests of 16 different crops.

3. Wetlands

   Information on carbon content in various peatsoils in different parts of Sweden can be obtained from the SLU database Markinfo /2000, www/. For production in low-productive peatlands, national averages can be obtained from Eriksson /1991/.

4. Lakes

   Information on total organic carbon (TOC) in lakes can be obtained from the database on lake water chemistry, hosted by SLU /2000, www/. Production values are only available in generic form, i.e. national averages for water bodies of different trophic levels (oligotrophic to highly eutrophic). These figures are found in a compilation made by Eriksson /1991/.

Spatial coverage and resolution

1. The Swedish NFI is implemented within defined circular **plots**, with the radius of 7 – 10 metres. The plots are clustered into **tracts**. The tracts are **systematically distributed** over the whole of Sweden. The distance between them is shorter in southern than in northern Sweden. The Swedish National Forest Inventory uses two kinds of tracts. One is temporary and the other permanent. The temporary tract is only surveyed once, where as a permanent tract is resurveyed regularly.

   The density of the tracts/plots is adjusted, by using information from a 5 year period, to give good precision for estimates at a county level.

   Data on carbon content in forest soils covers all forested land in Sweden.

2. Data on predicted yields (kg/hectare), is available on the county level and on the district level. The entire country is covered in these aspects.

3. Data on carbon content in peat soils covers the whole of Sweden.

4. Information on total organic carbon in lakes covers a large number of lakes in Sweden. The number of studied lakes in the counties of interest in the 1995 survey is as follows:

County	No. of studied lakes
Uppsala	65
Södermanland	34
Kalmar	106

Temporal resolution

1. The NFI is carried out in 10-year cycles. The statistic design is the same during each cycle, whereas the studied parameters can be modified in the middle of each cycle, i.e. every 5 years. Data on forest stands is available as 5-year averages, from 1923 and onwards. Data on soil carbon content from the SLU database Markinfo /2000, www/ is available from 1983–1987 as present (February 2000).

2. Yield data is available on an annual basis. The available time series is 1965–1998 as present (February 2000).

3. Data is available as 5-year averages, from 1923 and onwards. Data from the SLU database Markinfo /2000, www/ is available from 1983–1987 as present (February 2000).

4. Data on TOC in lakes are available from the national surveys for the years 1972, 1975, 1980, 1985, 1990 and 1995.

Statistical properties

Not applicable.

Methods/models used for existing data

1. The National Forest Inventory is carried out as random sampling of a nation-wide network of sample plots (see further above).

2. Unknown.

3. The National Forest Inventory is carried out as random sampling of a nation-wide network of sample plots (see further above).

4. The method used for determining total organic carbon in lakes is Svensk Standard SS 02 81 99

4.4.2 Methods for data collection

The available information is sufficient, and no additional data collection is necessary.

Background data needs

None.

Time schedule

Since the data already exists, the collection and compilation of it can be carried out at any suitable time.

Potential resources

The collection and compilation of relevant data can be made by SwedPower, or by other consulting agencies.

Effects on environment

None.

4.4.3 Costs

All data from the sources above are free of charge. Only costs for the time needed for data collection will be accounted for.

Material, special resources

None.

Time requirements

Collection, analysis and compilation of relevant data should be possible to accomplish within 60–80 person-hours of work.

4.4.4 Conclusions

The information in the different sources mentioned above is of varying resolution. Not all data is available in site-specific form, but a combination of regional data and generic (national) data is sufficient for enabling establishment of patterns of vegetation biomass on a regional scale, and furthermore for calculations of carbon flows in the ecosystems of current interest.

4.5 Species (flora)

The information here is a description on where or how to obtain information on occurring species of vascular plants, algae, fungi, mosses and lichens. The information compiled is focused on terrestrial and fresh water species, whereas marine species are excluded.

4.5.1 Existing data

Vascular plants

Nation-wide surveys of vascular plants, or any other floral organism groups for that matter, do not really exist. For several counties, however, floral surveys have been performed or are presently being carried out. In these surveys, all 5 x 5 km squares have been, or will be, studied with regards to existing vascular plant species. To date, 7 provincial floras have been published. For several other counties, including those of current interest, surveys are presently being carried out /Gustafsson and Ahlén, 1996/. While the work is in process, it is possible to get data from squares already inventoried /Jonsell, 1999, pers. comm./.

For some smaller areas, e.g. the municipality of Oskarshamn, similar surveys have been accomplished. One example is Floran i Oskarshamns kommun /Rühling, 1997/. Here, the vascular plants of the municipality of Oskarshamn have been surveyed. In all, 82 5 x 5 km squares were investigated during a 20-year period.

On the homepage of Swedish Environet, links for different organism groups are given. E.g., on one page /Svenska miljönätet, 1999, www/, it is possible to get a list of sources on vascular plants. One of the most interesting alternatives here is the county-wise

listing of articles from Svensk Botanisk Tidskrift (Swedish Botanical Magazine). This information is also available at the homepage of the Swedish Botanical Association /SBF, 1997, www/, where it is possible to get all articles dealing with the flora in a particular county.

Algae

Information on red-listed stoneworts (Charophyta, Characeae), can be obtained from ArtDatabanken. No other relevant information source has been found. But since 27 out of 33 stonewort species in Sweden are red-listed, the coverage can be regarded as fairly good.

Fungi

The Swedish Mycological Association (Sveriges mykologiska förening) has gathered data on findings of macrofungi in Sweden in a database /Hallingbäck, 1999, pers. comm./. The data from this database should be available.

Relevant published articles on the macro fungi in Sweden are found on SBF's internetpages /SBF, 1997, www/.

The coverage on red-listed macrofungi in the database of ArtDatabanken is very good /Hallingbäck, 1999, pers. comm./.

Mosses

Published material on surveys of mosses is given in a county-wise order on the Internet /Mossornas vänner, 1999, www/. The organisation responsible for that catalogue is Mossornas Vänner, Uppsala.

Lichens

The Swedish Botanical Association has also published a great deal of information on distribution and ecology of lichens, all articles in the Swedish Botanical Magazine on the lichenous flora in Sweden are listed on their Internet page /SBF, 1997, www/.

Spatial coverage and resolution

Vascular plants

During the Oskarshamn survey all 82 municipality squares were surveyed, but the total area in each square was not studied /Rühling, 1997/. Instead, the scope was to visit at least one representative site of the biotope types occurring in each square.

The most common species were registered at lest once per square, whereas positions for rarer species were registered in all sites they were found. The geographical position for the latter species were defined according to the grid Rikets Nät.

The provincial floras have approximately the same resolution and coverage /Gustafsson and Ahlén, 1996/.

Algae

The information from the database on red-listed stoneworts at ArtDatabanken should provide information on the distribution for 27 out of 33 species found in Sweden.

Fungi

It is not possible to obtain information on the coverage and resolution of the material mentioned above before the sites are selected.

Mosses

It is not possible to obtain information on the coverage and resolution of the material mentioned above before the sites are selected.

Lichens

It is not possible to obtain information on the coverage and resolution of the material mentioned above before the sites are selected.

Temporal resolution

Vascular plants

The work behind both the municipal flora of Oskarshamn, and the provincial floras, was carried out during a period of several years, the former between 1976–96. Regarding the latter studies, there have been similar surveys undertaken earlier, i.e. the present studies might be regarded as follow-up surveys /Gustafsson and Ahlén, 1996; Jonsell, 1999, pers. comm./.

Algae

See above.

Fungi

See above.

Mosses

See above.

Lichens

See above.

Statistical properties

It is not possible to use data from one area and establish a species list in another, even adjacent, area.

Methods/models used for existing data

Vascular plants

See above.

Algae

No information available.

Fungi

No information available.

Mosses

No information available.

Lichens

No information available.

4.5.2 Methods for data collection

The methods for data collection most suitable and relevant for the study depend on two things; the environmental characteristics of the sites that are to be studied, and the demand for precision.

For an overall knowledge on the floral constitution in the site, randomly or transect-wise arranged sample plots, or line inventory in different biotopes within the site is sufficient /Hallingbäck, 1999, pers. comm./.

If a total knowledge on all occurring species is desired, the total area of the site must be studied.

Suitable methods for vegetation surveys are given in Liljelund and Zetterberg /1987/.

Background data needs

Infrared aerial photographs and maps and very useful for selecting sites for sample plots, inventory transects etc., as well as for getting an overall picture of the sites.

Time schedule

All on-site floral surveys must be performed prior to the site surveys. Vascular plants should be surveyed during summer, but the best time for studying mosses, lichens and macrofungi is during the autumn.

Potential resources

ArtDatabanken /Hallingbäck, 1999, pers. comm./ recommends the consulting agencies Ekologigruppen, Naturcentrum and Pronatura. There are also a number of very competent persons not connected to a company, that can perform inventories of various kinds. It is possible to get recommendations from ArtDatabanken on suitable experts /Hallingbäck, 1999, pers. comm./.

Uncertainty – Risks

Whether using existing data or performing detailed surveys for data collection, it is not possible to establish a complete and full knowledge on all existing plant species even within a quite small area. Some species will inevitably avoid detection.

Effects on environment

None.

4.5.3 Costs

Existing data

The cost for deriving data from the 5 x 5 km squares in the provincial floras, is app. 3 000 SEK per square /Jonsell, 1999, pers. comm./.

The data from the database on red-listed species is free of charge.

Additional surveys

The cost for performing vegetation studies is very difficult to estimate. The size, location and complexity of the sites will determine the design and scope of the methods that are to be used, and thus the time needed for carrying out the studies. If all plant organism groups are to be surveyed, it is most likely that a staff of experts on the different groups need to be consulted. This would mean 3–4 experts. An early estimation is that each expert needs at least 4–6 weeks of work to study the area, and an additional 2–3 weeks to write a report. This would mean 18–36 weeks of work, or an approximate total cost somewhere in the span of 300 000–700 000 SEK.

Material, special resources

None.

Time requirements

See above.

4.5.4 Conclusions

Apart from the provincial floras on vascular plants, no all-encompassing surveys on the flora have been performed /Hallingbäck, 1999, pers. comm./.

For all organism groups above, data can be obtained from the database of ArtDatabanken (red-listed species) and quite often also from various inventories performed by different authorities, universities etc. However, since it is very time consuming to search for these latter inventories, the most feasible way to deal with this potential source of information is to await the decision on what sites that are to be surveyed and then try to locate these data.

It is our opinion that it is neither possible nor particularly relevant to have a full knowledge of all occurring plant species within the areas in question. Looking at vascular plant data from the 5 x 5-km squares in which the deep-level repositories might be placed may be relevant in the site selection process. But later on, as the site surveys and finally the construction work are initiated, having control of the occurring red-listed species (and key biotopes) is sufficient to take the necessary precautionary actions to comply with any relevant requirements.

4.6 Red-listed species

In this report, red-listed species are defined according to the "old" classification system, i.e. on the 0–4 scale and by the following definitions /e.g. Aronsson (ed.), 1999/:

0 Extinct. Taxa no longer known to exist in the wild (reproducing populations).

1 Endangered. Taxa at risk of vanishing and whose survival is unlikely if the causal factors continue operating.

2 Vulnerable. Taxa believed likely to move into the Endangered category (1) in the near future if the causal factors continue operating.

3 Rare. Taxa that are not at present Endangered or Vulnerable but are at risk because of small total populations within the area of concern.

4 Care-demanding. Taxa known to be Extinct, Endangered, Vulnerable or Rare, but where there is not enough information to say which of the categories is appropriate.

In the near future, the Swedish redlists will be revised and adjusted to the new global classification system developed by IUCN (the Swedish adaptation can be found on the homepage of ArtDatabanken /2000, www/.

4.6.1 Existing data

The authority responsible for the official Swedish redlists is ArtDatabanken (Swedish Threatened Species Unit). Besides the task of maintaining and updating these redlists, the unit also publishes books containing various information. For most organism groups, there are separate books that gives information on the species level, such as causes of the threat, maps on where the species have been registered etc /e. g. Aronsson, 1999/.

Information on red-listed species can also be found in various inventories and databases, holding data not yet incorporated in the ArtDatabanken database.

One example of this is the data base of Elfiskeregistret /2000, www/, the National register on results from electric fishing, that registers information on the fish fauna of investigated Swedish watercourses. Since some fish are put on the official redlist, registrations on these species from adjacent watercourses should be possible to derive.

Another possible source is the attribute data from the key habitat surveys (see above).

Spatial coverage and resolution

On the homepage of ArtDatabanken /2000, www/, a search engine is provided to allow visitors to search on red-listed species on various levels. The spatial resolution in the searchable database is limited to give information on registered red-listed species on the administrative county (län) level. By starting with this procedure it is, however, possible to narrow down the number of potentially existing red-listed species.

On request, additional information can be derived from the database, either at the species level (all records of a species), or defined by a specific area. In the latter case, all registered red-listed species within a given area can be given. This information

includes (in most cases) positions according to Rikets Nät (the national grid), date of finding, finder, references etc. However, the database is not complete, since the willingness to report findings to ArtDatabanken varies among the species experts in the country. According to ArtDatabanken /Lejfelt-Sahlén, 1999, pers. comm./, the coverage on flora and birds is very good, whereas invertebrates are less well documented in their database.

This means that it is possible to get specific information for the areas concerned, when chosen, but it also means that the information will not be entirely without data gaps.

Temporal resolution

In the database of ArtDatabanken it is very difficult to find any relevant information that consists of anything but one-time records, i.e., if the occurrence of one species is registered, it has mostly been registered once. It is possible to get information on the date of the recording however.

Statistical properties

By studying the distribution of key biotopes in an area, it is possible to say something about the (potential) occurrence of red-listed species. However, the resolution in ArtDatabankens database should be regarded as sufficient.

Methods/models used for existing data

Reports on findings of red-listed plants and animals are continually put into the databases. These reports are given by some thousand people, a majority being competent amateurs.

4.6.2 Methods for data collection

Since the data available, as described above, can be considered as sufficient, no additional field surveys need to be proposed.

4.6.3 Costs

The data from ArtDatabanken's database is free of charge. A written request with information on what organism groups and for what areas information is needed, is enough. Depending on the number and sizes of the areas in question as well as the time of the request (the workload at ArtDatabanken varies), the time of delivery varies between a few weeks and one or two months.

4.6.4 Conclusions

It is the present authors' viewpoint that the data in the ArtDatabanken database is sufficient for yielding the information necessary for the planned site surveys. It is possible, however, that additional information can be gathered from other sources. The best way to act is to await the decision on what sites should be surveyed and then make an additional effort to, if possible with regards to the actual sites, pin-point that extra data. E.g., since it is not clear whether any watercourses are within the affected area, it will not be useful to search for red-listed fish species in Elfiskeregistret prior to the

choosing of potential repository sites. The same line of argument as above is applicable regarding the attribute data from the key habitat surveys; only when the potential disposal sites are selected, will it be meaningful (with regards to time- and cost efficiency) to search for additional findings of red-listed species at the sites of current interest.

4.7 Species (fauna)

The information here is a description on where or how to obtain information on the distribution of mammals, birds, land molluscs and reptiles in terrestrial and fresh water habitats.

4.7.1 Existing data

Mammals

The Swedish Hunting Association (Svenska Jägareförbundet) is in charge of the national monitoring of game stock. The data consists mainly of shooting statistics for elk (moose) and roe deer, but also some other mammals and game birds /Kindberg, 1999, pers. comm./. For a few areas, data on elk (moose) populations from helicopter surveillance is available.

Some data is also available on large carnivores (wolf, bear and lynx), which, however, is of a limited interest for this purpose. During the year 2000, a nation-wide lynx survey will be carried out /Kindberg, 1999, pers. comm./.

In the Swedish National Atlas /Gustafsson and Ahlén, 1996/, some data is available on the approximate densities of elk (moose), but according to the Hunting Association (that delivered the original information), this data is based on shooting statistics and therefore relatively uncertain /Kindberg, 1999, pers. comm./.

At the county administrative boards and/or game-management associations (jaktvårdsförbund), shooting statistics are also available. Based on statistics from an area, it is possible to estimate the population density of game mammals and birds /Andersson B, 1999, pers. comm./.

Information on red-listed mammals (23 species or 1/3 of the mammal species in Sweden) can be obtained from the database at ArtDatabanken.

Birds

By the end of 1999, the Swedish Bird Atlas (Svensk Fågelatlas) will be published /Svensson, 1999, pers. comm./. This publication is a mapping of the distribution of nesting bird species in Sweden. In the book, each species is presented on a spread with a distribution map and text. The text gives additional information on e. g. the distribution, habitat use etc., of the species.

Another source of information is the nesting inventory programme (häckfågeltaxeringen), which is carried out on a yearly basis in most parts of Sweden /Andersson B, 1999, pers. comm./.

Reptiles

The distribution of red-listed reptiles is possible to obtain through ArtDatabanken (see red-listed species), otherwise their distribution is poorly documented.

Land molluscs

At the museum of Natural History in Gothenburg, a database on land molluscs is under construction. Land molluscs are sensitive for changes in the environment, and thus very suitable for monitoring purposes /von Proschwitz, 1998/.

Spatial coverage and resolution

Mammals

The data assembled by the Hunting Association covers most parts of the country /Kindberg, 1999, pers. comm./. On the hunting district level (app. municipal level), the goal is to have a coverage of at least 25% of the area from which the shooting parties report their shooting statistics /Kindberg, 1999, pers. comm./.

Information on red-listed mammals has a good spatial coverage, since all reported findings in Sweden are available here.

Birds

The Swedish Bird Atlas contains bird records from more than 12 000 out of 19 000 of Sweden's 5 x 5 kilometre atlas squares. The gaps are mainly situated in the northern part of Sweden, whereas the coverage in the southern part is nearly complete.

It is possible to request square-wise information from Sören Svensson, University of Lund. For each square, a list of possible, probable and definite breeding species is given. Nothing is, however, said about the number of breeding pairs etc, i.e. no quantitative information is available here. The field survey was conducted during 1974–86, but the written information on each species' distribution is updated with the latest possible data. The distribution map is entirely based on the survey, and is thus not updated.

Local registrations of red-listed bird species are possible to get from ArtDatabankens database (see above).

The nesting bird inventory programme is carried out by counting nesting birds, both occurring species and numbers of individuals, in sample plots and along routes /Andersson B, 1999, pers. comm./. This information can provide quantitative data on bird populations, but has a more narrow resolution, being a sample plot survey. Information from sample plots can be obtained from the University of Lund /Svensson, 1999, pers. comm./.

Reptiles

No data besides information on red-listed reptiles is available. However, since nearly 2/3 of the reptile species in Sweden are red-listed, that information can be regarded as having relatively good coverage.

Land molluscs

In the database at the museum of natural history, the data coverage (number of sample sites) in the municipalities in concern is as follows:

Municipality	No. of sites	No. of re-visits	Total no. of samples
Oskarshamn	138	0	138
Hultsfred	161	1	162
Nyköping	201	0	201
Östhammar	157	5	162
Älvkarleby	44	0	44
Tierp	118	0	118

As seen above, a major part of the sample sites have only been surveyed once.

In the database, the information is given on; 1) the position of the sample site, 2) a biotope description and 3) a list of found species.

Temporal resolution

Mammals

Shooting statistics for at least elk (moose) and roe deer is available for longer time series /Kindberg, 1999, pers. comm./.

Birds

The nesting bird inventory programme has been carried out since 1969 (sample plots) and 1975 (routes). This means that there is a reasonably high temporal resolution.

Reptiles

See above.

Land molluscs

See above.

Statistical properties

Mammals

Based on the average game stock in a larger area, e.g. a county, it is possible to give estimations on the stock in a smaller area, e.g. a municipality /Andersson B, 1999, pers. comm./.

Birds

For a comparative purpose, it should be feasible to use data from the 5 x 5 km squares as valid for an area within the square.

Reptiles

Not applicable.

Methods/models used for existing data

Mammals

Game stock estimations are generally based on shooting statistics /Kindberg, 1999, pers. comm.; Andersson B, 1999, pers. comm./. For some areas helicopter surveillance can give more reliable data on mainly elk (moose) stocks /Kindberg, 1999, pers. comm./.

Birds

See above.

Reptiles

See variable 4.6 Red-listed species.

4.7.2 Methods for data collection

Mammals

According to studies made at Grimsö research station, pellet counts is a feasible method for estimating stocks of roe deer, hare and forest game birds /Pehrson, 1997/. Simulations have shown that by carrying out field surveys in 0.05% of the total study area, in this case 2 000 hectares, a reliability of ± 20% is achievable at least in every second survey /Pehrson, 1997/.

A number of other methods for game stock estimations are given in Pehrson /1997/.

Birds

A number of different standardised methods are available /Naturvårdsverket, 1978/. Which one to chose depends on the purpose of the study (demand for precision) and the site's characteristics. Given the relatively small areas that are to be studied, it should be possible to perform all-encompassing surveys. A territory inventory covering the entire area is recommended /Berg, 1999, pers. comm./.

Reptiles

No suitable method has been found.

Background data needs

Mammals

Shooting statistics is necessary for making stock estimations of game mammals /Andersson B, 1999, pers. comm./.

Birds

None.

Reptiles

Not applicable.

Time schedule

Mammals

Mammal surveys must be performed before the area is disturbed by site surveys. The best time of year for carrying out the surveys depends on the method used. Pellet count surveys for estimating stocks of roe deer, hare and forest game birds should be carried out during spring /Pehrson, 1997/.

Birds

The bird fauna should be surveyed prior to the site surveys, and during spring/early summer.

Reptiles

Not applicable.

Potential resources

Mammals

The game-management associations (jaktvårdsföreningar) in the respective counties are suitable for performing game stock estimations /Andersson B, 1999, pers. comm./.

For stock estimation surveys, e.g. pellet counts, the staff at Grimsö research station should be engaged.

Birds

The institution for conservation biology can perform bird surveys /Berg, 1999, pers. comm./. They have the proper competence as well as the experience necessary.

Reptiles

Not applicable.

Uncertainty – Risks

When surveying animals, there is always a risk of missing some individuals of the surveyed species. Using the methods recommended here, and by engaging competent staff, that risk should be minimal.

Effects on environment

None.

4.7.3 Costs

Existing data

Mammals

The information obtainable from the Hunting Association, the county administrative boards etc., e.g. shooting statistics, is free of charge.

Birds

Raw data from the 5 x 5 km squares of the Swedish Bird Atlas is possible to request from the data owner /Svensson, 1999, pers. comm./. The cost for this will be app. 5 000 SEK.

Data from the nesting bird inventory need to be compiled and analysed, which will cost app. 20 000 SEK /Svensson, 1999, pers. comm./.

Additional surveys

Mammals

The prime costs, excluding travel costs, for various species inventories, and based on the index year 1995, are given in Pehrson /1997/. In the table below, the costs for some of these survey methods are given, as well as the area studied in the survey.

Species	Method	Output	Area (ha)	Time (man-days)	Cost (SEK)
Hare	Line transect sampling on snow	No. of disturbed hares/1000 ha	2 000	30	54 000
Squirrel	Surface inventory	No. of squirrels/ km²	100	6	5 500
Game birds	Line transect sampling on snow	No. of disturbed birds/1000 ha	9 000	40	37 000
Black grouse	Mating ground survey, total count	No. of males/1000 ha	13 000	15	14 000
Hare, roe deer and forest game birds	Pellet counts in squares	No. of pellets per ha and day (possible to use for density calculations)	2 000	40	36 000

Birds

Based on the assumption that the whole area is forested, the cost for an all-covering territory mapping (as above) is app. 200 000–300 000 SEK. This includes 24 mornings and 6 nights of sampling and one additional person-month of work for reporting /Berg, 1999, pers. comm./.

Material, special resources

None.

Time requirements

See above.

4.7.4 Conclusions

Mammals

The information on red-listed mammals in combination with game stock estimations, will give a sufficient level of knowledge.

Birds

The data (birds) is not assembled with a sufficient resolution. From the sources given above, a gross list for a specific area is possible to derive. The variation between different years is substantial, and the position of the species registration is not sufficient. For the site selection process, this information could be sufficient, since it will be possible to compare species richness between the sites in question.

Reptiles

Most important is to keep track of the red-listed reptile species, which is possible by searching on ArtDatabanken's database. No standardised survey methods are available for this purpose, and the authors' opinion is that it is not necessary to have an all-encompassing picture of the distribution of the reptile populations. Since a major part of the reptiles are red-listed, that information is sufficient.

4.8 Biomass (fauna)

The information here is a description on where or how to obtain information on the total mass of herbivores, carnivores and destruents, respectively.

4.8.1 Existing data

Some information from Variables 4.7 Species (fauna) and 2.1 Fish is relevant also for this purpose.

Benthic fauna

Institutionen för miljöanalys at SLU, is hosting a database on benthic fauna that is accessible via Internet /2000, www/. The data comes from various national surveys of lakes and running waters. In the lake surveys, the biomass of benthic fauna per site has been studied for several sites, but with a varying temporal resolution.

Fish fauna

Average densities of fish species in running waters is possible to obtain from Elfiske-registret. Nothing is said about the weight of the fish, but information on the age structure will allow estimations of both production and total weight/area (see also variable 2.1. Fishery).

Game mammals

Shooting statistics can be used for estimating stocks of game mammals /Andersson B, 1999, pers. comm./. This information is available at the national hunting association, the county administrative boards, game management associations etc. (see also variable 4.7 Species (fauna).

Spatial coverage and resolution

Benthic fauna

In the counties of current interest, the number of survey sites is as below.

County	No. of sites
Uppsala	10
Södermanland	14
Kalmar	5

Fish fauna

See variable 2.1 Fishery.

Game mammals

Shooting statistics should be available for most parts of the country /Kindberg, 1999, pers. comm./.

Temporal resolution

Benthic fauna

The temporal resolution varies between the different lakes, but for most lakes data is available from 1995 and onwards.

Fish fauna

See variable 2.1 Fishery.

Game mammals

Shooting statistics are normally available for a series of several years /Kindberg, 1999, pers. comm./.

Statistical properties

Benthic fauna

No information on the possibility of using non site-specific, or generic, data has been found.

Fish fauna

See variable 2.1 Fishery.

Game mammals

If relevant data is available for an area adjacent to a survey site, the data should be applicable for use in an assessment, given that the environmental characteristics are similar for both areas.

Methods/models used for existing data

Benthic fauna

The methods used for the surveys in the mentioned database are kick sampling in shallow waters and sampling with Ekman sampler in deeper waters.

Fish fauna

See variable 2.1 Fishery.

Game mammals

Game stock estimations are generally based on shooting statistics /Kindberg, 1999, pers. comm./.

4.8.2 Methods for data collection

Benthic fauna

In the methodology handbook published by the SNV, suggestions of methods for surveying benthic fauna, including biomass measurements, are given /Rosén, 1993/. Two standard methods are given, sampling on soft bottoms (SS 02 81 90) and sampling in running waters (SS 02 81 91).

Fish fauna

By means of electric fishing (running waters) and net fishing (lakes), it is possible to estimate the biomass of fish per area. An even better method for measuring the fish fauna biomass in lakes, is a combination of net fishing and hydro-acoustic surveys (see also variable 2.1 Fishery).

Game mammals

Existing suitable methods for stock estimations are given and analysed in Pehrson /1997/. Out of the methods available, pellet counts seems to be the most relevant and cost-effective one.

Background data needs

Benthic fauna

None.

Fish fauna

See variable 2.1 Fishery.

Game mammals

Shooting statistics are needed for stock estimations.

Time schedule

Benthic fauna

The species composition and richness of individuals of benthic fauna varies substantially during the year /Rosén, 1993/. The best time to perform surveys is in the spring and/or in the autumn. If additional surveys are needed, they should be performed both during springtime (early April) and autumn (during the autumn circulation).

Fish fauna

See variable 2.1 Fishery.

Game mammals

Stock estimations can be performed at any time.

Potential resources

Benthic fauna

The consulting agency Ekologen Kjell Frick AB has been engaged by SwedPower on several occasions, and has performed thorough studies. We can, therefore, recommend that firm.

Fish fauna

See variable 2.1 Fishery.

Game mammals

Shooting statistics are needed for stock estimations.

Effects on environment

None.

4.8.3 Costs

Existing data

Benthic fauna

The data available at SLU is free of charge.

Fish fauna

See variable 2.1 Fishery.

Game mammals

Stock estimations can be performed free of charge by the Hunting Association and by the regional game-management associations /Kindberg, 1999, pers. comm.; Andersson B, 1999, pers. comm./.

Additional surveys

Benthic fauna

A benthic fauna survey programme for aiming at total weight estimations will not need to be particularly costly. Given a small stream, 10–20 samples should be sufficient. The sampling could be performed in a time of no more than 2 days, and sorting, drying and weighing of the samples would take approximately an additional 2 days of work. Excluding travel costs and expenses, this would amount to app. 25 000 SEK.

Sampling a medium-sized lake would be approximately similar in its scope and costs. Some additional sampling sites would possibly be needed.

Fish fauna

See variable 2.1 Fishery.

Game mammals

See variable 4.7 Species (fauna).

Material, special resources

Benthic fauna

Normal benthic fauna sampling equipment (bag nets, Ekman sampler etc.), including a boat.

Fish fauna

See variable 2.1 Fishery.

Game mammals

None.

Time requirements

Benthic fauna

See above.

Fish fauna

See variable 2.1 Fishery.

Game mammals

See above and variable 4.7 Species (fauna)

4.8.4 Conclusions

The data available is very limited, and with a relatively high degree of uncertainty. On the other hand, establishing a satisfying baseline will require a large effort, which may lead to the conclusion that the existing data is regarded as acceptable. The exception being benthic fauna surveys that, depending on the sites, are relatively easy to perform and not so costly.

Regarding methods for data collection in aquatic environments (freshwaters), methodology descriptions given on the homepage of the SNV /1999, www/, and in the methodology handbook published by SNV /Rosén, 1993/ are recommended.

5 Variable group Hydrology

Hydrology is the science of waters of the earth, their occurrence, distribution, and circulation; their physical and chemical properties; and their reaction with the environment, including living beings. Water is a link between the geosphere and the biosphere. This makes hydrology a very important issue in the selection of a location for repository of nuclear waste. A careful study of hydrological variables is needed as background data for the site investigations and for future monitoring and evaluation programmes. The safety assessment needs data regarding the hydrology for calculations of transport, accumulation and chemical processes. The data is also needed for the general understanding of biosphere variables in the area.

5.1 General descriptions of the data sources

SMHI – the Swedish Meteorological and Hydrological Institute is a public institution. They collect data trough their own network of observation sites and also buy data from others. The databases contain data from all catchment areas draining to Sweden in the form of registers and characteristics for catchment areas, lakes and watercourses. SMHI also processes data and constructs models. Data can be purchased from SMHI. Even though they are a governmentally funded institute, they charge for their services, including basic data records.

The Department of Environmental Assessment at the Swedish University of Agricultural Sciences (Institutionen för miljöanalys, SLU) is the official data host for chemical and biological variables in fresh waters. They have data from all national and some regional studies. The laboratory is accredited by SWEDAC for both chemical and biological analyses. The data is available on the department's homepage /2000, www/, where also current and past methods of analysis are described. The database encompasses time series from as far back as the 1960's. Sites and sampling frequencies are listed on the homepage. Data is available through the Internet or by request.

Municipalities (kommuner) and County administrative boards (länsstyrelser) have their own programmes for recipient control and environmental monitoring. The data from these programmes are some times reported to the Department of Environmental Assessment. In other cases the data is stored locally, e.g. at water management associations. The quality is often quite good and comparisons are possible since most programmes follow the practice in "Naturvårdsverkets metodhandbok – vatten" /Rosén, 1993/. The availability of data varies. In many municipalities initiatives have been taken to gather all data and store it in a more available form. The municipalities have data of varying quality, range, length and resolution, so it is not possible to give any general description of the data sets. Since data is generated in different investigation programmes with different scopes, the variation can be substantial even within a community. In general, the municipalities are concerned with monitoring the environmental status in recipients. Recipients are mostly located near residential areas or industries, i.e. in areas that will probably be unsuitable for deep-level waste repositories.

Most of the data from the county of Uppsala has been reported to the Department of Environmental Assessment, but some local programmes store their data at municipalities and water associations.

The data from Nyköping is of very varying quality. Since water bodies stretch across the borders between municipalities, the data from one municipality might be stored in another. Nyköping is one of the municipalities that are considering a re-organisation of their data.

Hultsfred has recently put in place a new programme for environmental control with high temporal and geographical resolution.

The other community of interest in the county of Kalmar, Oskarshamn, has older, much less ambitious, programmes.

5.2 Water level

Water level is the level assumed by the surface of a particular body or column of water.

5.2.1 Existing data

Water levels are often measured to get information about the water flow at certain points, see 0 Water retention time below.

SMHI – the Swedish Meteorological and Hydrological Institute measures the water level, continuously or at least once a day, in 119 lakes. Moreover, many lakes and watercourses in Sweden are regulated, and thus have carefully recorded data on water levels. This data may also be obtained through SMHI.

Spatial coverage and resolution

The entire country is covered by SMHI, but in a quite coarse grid. In locations with many hydropower plants or other impoundments the resolution might be much better.

Temporal resolution

The temporal resolution is almost always extremely good. Most observation sites measures the water level continuously and registers average values for each hour. The lengths of the time series differ, the oldest series that continues today started 1774 in Stockholm.

Statistical properties

Various kinds of statistical features, on several geographical levels, are produced by SMHI.

Methods/models used for existing data

See below.

5.2.2 Methods for data collection

There are no standard methods for measuring water level in Sweden. Almost all permanent equipment need local adaptations. If long series of data are needed, then permanent equipment, such as a gauge with an automatic recorder, is to be preferred. SMHI is the authority responsible for supervision. They do not have any other rule than that the equipment shall generate correct results /Olsson, 1999, pers. comm./. They are very liberal towards the use and testing of new methods, as long as the results are accurate. Olson /1999, pers. comm./ mentioned “Guide to hydrological practices” /WMO, 1994/ as a source of descriptions, models etc. for the entire field of operational hydrology.

The U.S. Department of the Interior has, in co-operation with the U.S. Department of Agriculture, issued a “Water measurement manual” which can be used as a guide for the selection of methods for data collection /USBR, 1997, www/.

It also possible to generate water level data using the HBV model described below.

The unit of measurement is centimetres. SMHI is controlling authority /Olsson, 1999, pers. comm./.

Background data needs

None.

Time schedule

With continuous measurements, all the interesting events, such as floods etc., will be recorded. To get some idea about the variation over and between years, a time series of at least three years is needed. To get statistically reliable values, and to be able to see trends in the variations, a minimum of ten years is required. These time series could also be generated with some kind of hydrological model. With discrete measurements it is very important to make sure to capture the extreme events.

Potential resources

SMHI, SwedPower AB, other consulting firms.

Data processing

With an automatic gauge equipped with data logger and connected by radio or telephone, the time required for data processing is very short. With a continuous analogue registering device the extraction of data may consume a lot of time. With a staff gauge the water level has to be read and sent in manually, the time consumption for this varies considerably with travel time.

Uncertainty – Risks

The accuracy of measurement is to the nearest centimetre. SMHI is controlling authority /Olsson, 1999, pers. comm./.

Impacts on the environment

Water level measurement devices vary greatly in terms of the disruption to existing conditions that are caused by installation, operation and maintenance. The changes in the flow conditions can alter local channel erosion, local flooding, public safety, local aquatic habitat, and fish movement up and down the channel.

The use of the HBV-model has no known effects on the environment.

5.2.3 Costs

The cost for a single measurement depends to a great extent on the equipment and the travel time involved. A new gauging site costs approximately 200 000 SEK /Ströberg, 1999, pers. comm./.

SMHI's prices are; Daily average 1.20 SEK, Monthly average 12 SEK, Long term average for a month 650 SEK /SMHI, Kundtjänst, 1999, pers. comm./.

Materials, special resources

Depends on which method is adopted, it varies from a simple staff gauge to hi-tech electronic devices.

Time requirements

The time requirement is dependent on the method as well as on the ambition of the monitoring programme, and last but not least, the distance to the observation sites.

5.2.4 Conclusions

The local surroundings and environment has such a great impact on the choice of best method for determining water level that the only guideline that can be given at this point is that an experienced person/company should handle site selection and installation.

If the cost for a gauging site has to be allocated entirely to the measurement of water levels and water flow, then the economic break-even point between continuous and discrete measurements comes after about 3 years. This means that it is not possible to save money by only doing discrete measurements. Yet another issue is that continuous values are vital for the calculation of material transport. To save money, the HBV-model could be used with some support from current-meter measurements to calibrate and validate the model. If time constraints speak against the use of flumes or weirs, then a combined approach, modelling the past and measuring the present with current meters, should be adopted.

The existing data is probably not sufficient unless there already is a gauging site nearby.

5.3 Water retention time

The concept of water retention time is expressed as the volume of the water body (m^3) divided by the water flow (m^3/s). This gives a theoretical value for the time it takes to replace all the water in a given water body.

5.3.1 Existing data

Since water retention time is derived by simple calculation from measurements of volume and flow, the following discussion will concentrate on these two parameters.

Data on lake volumes can be found in SMHI /1996/. It lists all lakes with a surface area larger than 0,01 km^2. Table C contains data regarding the lakes' surface areas and/or volume.

"Vattenföring i Sverige" /SMHI, 1993/ contains data on water flow from most observation sites in Sweden.

In their control programmes for water recipients, county administrative boards have to measure the water flow in order to obtain information about the transport of compounds.

In "Vatten i Uppsala län 1997" /Brunberg and Blomqvist, 1998/ all water bodies in the county of Uppsala are described. The theoretical water retention time is one of the parameters.

Spatial coverage and resolution

The spatial coverage and resolution concerning the lake volumes is excellent since almost all lakes in Sweden are measured and listed.

Today SMHI operates 467 observation sites for determining water flow. Data exists for 1047 sites. Apart from SMHI's measurements, hydropower plants, municipalities, water associations etc., also generate data on water flow.

SMHI has not built any observation site since the middle of the 80's, and discussions are held regarding the discontinuation of some sites. The combination of actual observations and the use of models have rendered some of the sites redundant. The conclusion is the responsible authority considers the coverage and resolution more than satisfactory.

Temporal resolution

The lake volume has, in most cases, only been measured once. Therefore it is very important to check that drainage or impoundments haven't altered the lake volume.

The temporal resolution of flow measurements depends on the location. Most sites have results for every hour, but SMHI recalculates these to daily averages. Some sites report weekly values. The temporal resolution is very good.

Statistical properties

The statistical data in “Vattenföring i Sverige” is of very good quality. Yearly and monthly averages, max and min, duration etc., are listed for all sites.

Many other kinds of statistical characteristics can be obtained from SMHI.

Methods/models used for existing data

The lake volumes are calculated from depth charts and maps supplied by municipalities and fishery conservation associations.

As with the variable “water level” above, the most common method has been the use of gauges, but current meters and hydropower plants have also been used.

SMHI has developed models for the calculation of evaporation, water flow etc. The HBV-model can be said to extrapolate data from actual measurements to other geographical points in a catchment area. Once the parameters for an area have been set, the cost of generating new values is quite low.

Descriptions of the methods used in the control of recipients are found in “Naturvårdsverkets metodhandbok – vatten”/Rosén, 1993/.

5.3.2 Methods for data collection

See above.

Background data needs

The HBV-model has high background data requirements. The cost of all necessary data is included in the price cited below.

Time schedule

The time schedule obviously depends on the method adopted. For compliance monitoring, single flow measurements with a current meter once a month at normal flow and once a week at high flows, such as snow melt, is sufficient. If the purpose instead is to gain an understanding of the actual processes in a lake, stream and catchment area, then a fixed gauging site is needed. Based on the assumption that the water body in question adheres to the expected behaviour of water bodies of that kind, a model, such as HBV, can be used.

Potential resources

SMHI, SwedPower, other consulting firms.

Data processing

The data from actual measurements has to be recalculated to water flow and further to water retention time.

Uncertainty – Risks

The degree of uncertainty in the HBV-model is about ±10%.

Effects on environment

Water level measurement devices vary greatly in terms of the disruption to existing conditions that are caused by installation, operation and maintenance. The changes in the flow conditions can alter local channel erosion, local flooding, public safety, local aquatic habitat, and fish movement up and down the channel.

The use of the HBV-model has no known effects on the environment.

5.3.3 Costs

A new gauging site with automatic logging and radio communication costs approximately 200 000 SEK /Ströberg, 1999, pers. comm./. For single measurements, a current meter might be appropriate. One measurement costs around 6 000 SEK. (Ibid., 1999).

To obtain calculated values on water flow for ten years using the HBV-model might, very approximately, cost about 50 000 SEK. /Amrén, 1999, pers. comm./

Material, special resources

Depends on method.

Time requirements

Depends on method.

5.3.4 Conclusions

See 0 (5.2.4 Conclusions under Water level).

5.4 Nutrients/toxins

Nutrients are substances that can be metabolised by an organism to give energy and build tissue. An element or compound essential to life, including carbon, oxygen, nitrogen, phosphorus, and many others.

Toxins can be defined as the opposite to nutrients, a material that can cause acute or chronic damage to biological tissue following physical contact or absorption. Toxin is a general term for any poisonous substance. Any liquid, gaseous, or solid substance or substances in a concentration which, when applied to, discharged to, or deposited in water or another medium may exert a poisonous effect detrimental to people or to the propagation, cultivation, or conservation of animals, or other aquatic life /Water Words, 1997, www/.

Nutrients of interest in this study are: P/N ratio, tot-P, tot-N, org-P and org-N.

Toxins of interest are: As, Cd, Co, Cr, Cu, Hg, Ni, Pb, V and Zn.

If the object is to save money, one could argue that since the production, in almost all water bodies in the areas under consideration, is limited by the availability of phosphorus, it is not necessary to measure the other nutrient parameters.

Aluminium is highly toxic in environments with low pH, consequently it should be included in the list above if the pH is lower then approx. 5.

5.4.1 Existing data

The Department of Environmental Assessment (Swedish University of Agricultural Sciences) is data host for chemical and biological variables in fresh water. They are responsible for collecting and storing the data from the national environmental monitoring programme for lakes and watercourses. They also have data from regional studies. Sometimes, data is not reported to the department, in which cases the county administrative boards usually have the data, or can give information on where to find it.

The data sets are divided into the following categories:

Lakes:

National lake surveys (measurements of approximately 3 000 lakes every five years), National reference lakes (time series), Regional reference lakes (time series), Reference lakes extended programme (integrated, intensive surveillance of lakes), Integrated liming assessment IKEU (follow-up of long-term effects of liming).

Sites in the municipalities of interest:

National lake surveys:	Several.
National reference lakes:	Rundbosjön, Djupa Holmsjön and Björken lie in the municipality of Nyköping, Tängersjö is situated in Hultsfred.
Regional reference lakes:	Vikasjön is situated in the community of Östhammar.
Reference lakes extended programme:	None.
Integrated liming assessment:	None.

Watercourses:

National watercourse surveys (first conducted in 1995, in connection with the national lake survey, containing data from about 700 watercourses). Regional reference watercourses (time series since 1995). Intensively monitored watercourses. River mouths (the observation sites often lie upstream from urban areas and measure the compound transport from 85% of the Swedish land area).

Sites in the municipalities of interest

National references:	Kila is situated in the south-west corner of the municipality of Nyköping.
Regional references:	Herrgårdsdammen is located in the central part of Österbybruk, Östhammar.
	Västra Ekeby is situated on Vendelån in the very south of the municipality of Tierp.

Intensively monitored watercourses:	Morån is located some 15 kilometres west of the southern tip of the municipality of Oskarshamn in the municipality of Högsby.
River mouths:	Dalälven at Älvkarleby, Forsmarksån at Johannisfors in Östhammar, Nyköpingsån at Spånga in Nyköping, Botorpström at Brunnsö in Oskarshamn and Emån at Emsfors in Oskarshamn.

The county administrative boards have the responsibility for surveying water recipients. The quantity, quality and availability of this data vary strongly between counties.

Spatial coverage and resolution

The spatial coverage is very good. National surface water surveys have been done approximately every five years since the mid-70's. In the last survey (1995), samples were taken from 4 113 lakes and 696 streams. Lake surface area classes (>0,04 km^2) and county were used in the selection of the lakes, whereas two catchment area size classes (15–50 and 50–250 km^2) where used for stratifying streams. The counties had the possibility to include additional lakes in the studies. The resolution is also quite good, taking all the different data sets into account. The problem is, however, that it is very hard to draw conclusions about one water body mainly based on data about others.

A very thorough study of the chemical and biological status of 26 Swedish reference lakes for the period 1989 to 1993 was reported in "26 svenska referenssjöar 1989–1993" /Persson, 1996/. Unfortunately none of these lakes were situated in any of the communities of interest to this study. Since lakes and their surroundings come in all sizes, shapes and types, it is very difficult to make an accurate estimate of the present state in the lake from statistical data without good knowledge of the lake in question. Thus you still need primary data to assess the status of a lake. Even though the parameters of morphology of two lakes are almost the same they may be completely different regarding the nutrient status due to e.g. different land use in the catchment area.

Temporal resolution

The database contains series, sometimes from as far back as the 60's, of measurements of the chemical properties of water. The resolution, however, differs substantially between sites and variables. In most cases the resolution is not good enough for the purpose of this study.

Statistical properties

The data has been handled by both the Swedish Environmental Protection Agency and by Statistics Sweden (SCB). The geographical and temporal statistical properties are not useful for the purpose of this study, since the differences between lakes in the same area can bee very large.

Methods/models used for existing data

A variety of different methods of analysis have been used to generate existing data. Since August of 1995, the Department of Environmental Assessment have used a Perkin-Elmer ELAN 6000 instrument to measure the content of metals in water. The

nutrient concentration measurements have changed a lot over time. Today all methods comply with Swedish Standard.

5.4.2 Methods for data collection

Swedish standard methods (SS or SIS) should be used. Existing sampling standards:

SS 02 81 94, “Sampling of natural waters for determination of trace metals”.

SS-EN 25667-2 “Water quality – Sampling – Part 1: Guidance on the design of sampling programmes (ISO 5667-1:1980).

SS-EN 25667-2 “Water quality – Sampling – Part 2: Guidance on sampling techniques (ISO 5667-2:1991)”.

SS-EN ISO 5667-3 “Water quality – Sampling – Part 3: Guidance on the preservation and handling of samples”.

Nutrients

Substance	Standard methods of analysis
Tot-N	SIS 02 81 31 SS-EN ISO 11905-1
Tot-P	SS-EN 1189
NH_4-N	SIS 02 81 34
NO_2+NO_3-N	SIS 02 81 33
PO_4-P	SS 02 81 26

Toxins/metals

Substance	Standard methods of analysis
As	SS-EN ISO 11885 SS-EN 26595 SS-EN ISO 11969
Cd	SS-EN ISO 11885 SS-EN ISO 5961
Co	SS-EN ISO 11885 SS 02 81 84 SS 02 81 52
Cr	SS-EN ISO 11885 SS-EN 1233
Cu	SS-EN ISO 11885 SS 02 81 84 SS 02 81 52

Substance	Standard methods of analysis
Hg	SS-EN ISO 11885 SS-EN 1483 SS-EN 12338
Ni	SS-EN ISO 11885 SS 02 81 84 SS 02 81 52
Pb	SS-EN ISO 11885 SS 02 81 84 SS 02 81 52
V	SS-EN ISO 11885
Zn	SS-EN ISO 11885 SS 02 81 52

Recommended methods:

As " Water quality – Determination of arsenic – Atomic absorption spectrometric method (hydride technique) (ISO 11969:1996)" SS-EN ISO 11969.

Cd SS-EN ISO 5961 " Water quality – Determination of cadmium by atomic absorption spectrometry (ISO 5961:1994)" SS 02 81 84 T1 " Metal content of water, sludge and sediment determined by flameless atomic absorption spectrometry – Special guidelines for aluminium, lead, iron, cadmium, cobolt, copper, chromium, manganese and nickel".

Co SS 02 81 84 T1 " Metal content of water, sludge and sediment determined by flameless atomic absorption spectrometry – Special guidelines for aluminium, lead, iron, cadmium, cobolt, copper, chromium, manganese and nickel".

Cr SS-EN 1233 "Water quality – Determination of chromium – Atomic absorption spectrometric method" SS 02 81 84 T1 " Metal content of water, sludge and sediment determined by flameless atomic absorption spectrometry – Special guidelines for aluminium, lead, iron, cadmium, cobolt, copper, chromium, manganese and nickel".

Cu SS 02 81 84 T1 " Metal content of water, sludge and sediment determined by flameless atomic absorption spectrometry – Special guidelines for aluminium, lead, iron, cadmium, cobolt, copper, chromium, manganese and nickel".

Hg SS-EN 12338 "Water quality – Determination of mercury – Enrichment methods by amalgamation" SS-EN 1483 "Water quality – Determination of mercury".

Ni 02 81 84 T1 " Metal content of water, sludge and sediment determined by flameless atomic absorption spectrometry – Special guidelines for aluminium, lead, iron, cadmium, cobolt, copper, chromium, manganese and nickel".

Pb 02 81 84 T1 " Metal content of water, sludge and sediment determined by flameless atomic absorption spectrometry – Special guidelines for aluminium, lead, iron, cadmium, cobolt, copper, chromium, manganese and nickel".

V SS-EN ISO 11885 " Water quality – Determination of 33 elements by inductively coupled plasma atomic emission spectroscopy (ISO 11885:1996)".

Zn An international standard on the use of Inductively Coupled Plasma – Mass Spectrometry, ICP MS, is under elaboration. It might take 2 –3 years to get this new standard ready. Until then SWEDAC accredited laboratories may use ICP MS as long as the accuracy and detection limits are adequate.

The most important issue regarding the different methods of analysis is that the method used must be able to give correct values on concentrations lower than the background values in southern Sweden. If a laboratory is accredited for a certain substance and a certain concentration limit by SWEDAC, it has proved its ability to accurately measure the concentration of that substance down to the specified limit. The laboratory should also be able to choose collection method to ensure that the samples are not contaminated.

Background values on metals in water in southern Sweden.

	Cu	Zn	Cd	Pb	Cr	Ni	Co	As	V	Hg
Watercourses, larger [µg/l]	1,3	4,3	0,014	0,32	0,4	1,0	0,13	0,4	0,4	0,004
Lakes[µg/l]	0,5	2,0	0,016	0,24	0,2	0,4	0,06	0,3	0,2	0,004
Sediment [mg/kg dm]	20	240	1,4	80	15	10	N/A	10	20	0,16

Source: SNV Rapport 4913.
The background values in smaller watercourses are approximately the same as in lakes.

Background data needs

See table above.

Time schedule

The time schedule varies depending on the purpose of the study (for a discussion see SNV Rapport 3075). If the purpose is to monitor the chemical properties of the water in a lake, samples should bee taken at least four times a year. An extended programme with 6–8 samples a year gives a better resolution of the seasonal changes, and hence a better basis for the calculation of trends and cyclical courses of events. A high sample frequency is a prerequisite for quantifying biochemical processes in a lake, and gives a solid base for assessment and modelling of the present state and variation of the flora and fauna in the lake.

For watercourses, the situation is somewhat different. If the purpose is to measure the transport of substances from an area, the sample frequency need to be at least 12 times/year. If the catchment area < 100 km^2, the sample rate should be intensified during high and variable discharge. If the purpose is some kind of compliance monitoring, the general recommendation is a sample frequency of six measurements/year /Löfgren, 1993/.

The length of the time series needed depends on the intention of the study. To be able to separate between variations and true trends, a time span of ten years is desirable /Rosén, 1993/. For compliance monitoring it might suffice with three years /SNV, 1999/.

Potential resources

Department of Environmental Assessment.

Data processing

None.

Uncertainty – Risks

The uncertainty varies between substances and methods. It is important to be vigilant concerning the methods of collection so that the samples are not contaminated.

Effects on environment

None.

5.4.3 Costs

The analysis cost per sample for the obligatory variables was 800–1 000 SEK in April 1994 /SNV, 1999, www/.

The company AnalyCen AB offers analyses of nutrients and toxins to the following costs /Klingstedt, 1999, pers. comm./.

Substance	Cost/sample [SEK]
Tot-P	90:–
Tot-N	120:–
Org-P = TotP -PO_4-P	63:–
Org-N = TotN -(NO_3+NO_2+NH_4)	126:–
Metals (As, Cd, Co, Cr, Cu, Hg, Ni, Pb, V, Zn)	698:–

Data from the Department of Environmental Assessment can be obtained free of charge from the Internet, URL http://info1.ma.slu.se/.

Material, special resources

A Ruttner-collector costs 6 000 SEK.

Time requirements

A watercourse sample takes approximately five minutes to take. /SNV, 1999, www/ Sampling in a lake takes about 15–30 minutes. /SNV, 1999, www/. Travel time to and from the sampling site should be added to this.

5.4.4 Conclusions

If the intended site is close to an observation site in the same water system, there might be sufficient data available on some parameters. Probably this is not the case, which makes an observation programme needed. Values obtained by models or statistical operations will not suffice.

What really matters in the choice of method is that the laboratory is accredited to measure concentrations as low or lower than the background values.

5.5 Oxygen concentration

Oxygen concentration is the concentration of dissolved oxygen measured at a certain depth in a water body.

Measurements of the oxygen concentration is standard procedure, it is almost always done when water quality is tested. It is more rare, however, that the oxygen concentration is measured at different levels, in order to understand how the oxygen concentration changes with depth.

5.5.1 Existing data

Data on oxygen concentration can be found at the data host, i.e. the Department of Environmental Assessment and at the county administrative board through the control of water recipients and other supervisory activities.

Spatial coverage and resolution

The spatial coverage is very good – almost all lakes and watercourses in Sweden have been tested. The resolution varies strongly, the biggest problem is the resolution on the depth scale.

Temporal resolution

If the purpose is compliance monitoring, then sampling is only needed when the oxygen concentration is at its lowest, spring and autumn. If the purpose is knowledge about how stratification, wind, temperature etc., affect the oxygen concentration in the lake, then data from different depth levels for each month for a decade is needed.

Methods/models used for existing data

SS 02 81 14 –2 “ Determination of dissolved oxygen content in water – Titrimetric method” and Karlgren L., “Vattenkemiska metoder”

5.5.2 Methods for data collection

SS-EN 25814 “Water quality Determination of dissolved oxygen – Electrochemical probe method”.

SS-EN 25813 “ Water quality – Determination of dissolved oxygen – Iodometric method”.

Which of the above mentioned methods that is most appropriate depends on the local conditions.

Background data needs

Information on the lakes' depth morphology is needed to select the best point(s) for sampling.

Time schedule

For understanding of the processes in a lake, a monthly value for different depths over a decade is sufficient.

Potential resources

SwedPower AB, Department of Environmental Assessment, SMHI.

Uncertainty – Risks

Depends on method, the iodometric method, range of application 0.1 – 20 mg/l, is sensitive for the presence of oxidising and reducing substances. The variation is 0.03 – 0.05 mg/l. The electrochemical method, range of application 0.1 – 15 mg/l, is sensitive for gases that can diffuse through the membrane of the measuring device. The coefficient of variation is ±3% /Johanzon, 1999, pers. comm./.

Effects on environment

None.

5.5.3 Costs

Depends on method.

Material, special resources

Depends on method.

Time requirements

Depends on method.

5.5.4 Conclusions

Either of the above mentioned methods can be satisfactory, depending on the local conditions.

5.6 Layering, stratification

Stratification is the arrangement of a body of water, such as a lake, into two or more horizontal layers of differing characteristics, such as temperature, density, etc.

5.6.1 Existing data

The data that exists is either in the form of a temperature profile or in the form of an oxygen concentration profile. This means that this variable is covered by the variables oxygen concentration and temperature.

5.7 Light conditions/Transparency

The light conditions at a certain depth depend on the light on the surface and on how much light is absorbed in the passage down to the specified depth. Transparency is a measure of the portion of light that passes through water without distortion or absorption. The transparency is an important parameter for estimating the "kompensationsdjup/extinktionsdjup" i.e. where the light is insufficient for enabling photosynthesis. The amount of absorption and/or scattering can also be used to approximate the quantity of suspended solids in water (See section 0 below).

5.7.1 Existing data

The Department of Environmental Assessment has data on filtered and unfiltered absorbency at 420 nm in a 5 cm transparent vial from various water bodies.

Spatial coverage and resolution

Both coverage and resolution are good.

Temporal resolution

The temporal resolution varies from once every five years to once a month. The longest time series started in 1965.

Methods/models used for existing data

Chalupa /1963/.

5.7.2 Methods for data collection

The above mentioned method for measurements of absorbance and SS-EN 27027 "Water quality – Determination of turbidity (ISO 7027:1990)" for measurements of scattered and transmitted radiation. It describes two semi-quantitative methods (transparent cylinder, viewing disc) and two quantitative optical methods, namely measurement of the scattered radiation and the transmitted radiation. It also contains detailed directions for preparing the formazine solution and calibration of the turbidimeters. /Sigrist, 2000, www/.

If the actual amount of light at certain depths is of interest it is probably best to fit the devices for oxygen and temperature sampling with a photometer. Shading (and other

parameters not mentioned above), which can be connected to the concept of light conditions are not relevant to the aims of this study.

Time schedule

For compliance monitoring sampling once a month for a year is necessary.

Potential resources

The Department of Environmental Assessment, SLU.

Effects on environment

None.

5.7.3 Costs

Depends on the adopted method.

Time requirements

Depends on the adopted method.

5.7.4 Conclusions

The method has to be selected according to the medium and actual needs of the location.

5.8 Temperature

Temperature is the degree of hotness or coldness, a measure of the average energy of the molecular motion in a body or substance at a certain point. The measurement of temperature is standard proceedings in most surveys of water.

5.8.1 Existing data

Twice a year SMHI measures temperature profiles in eleven larger lakes in southern Sweden. None of these lakes are situated in the proximity of the municipalities in question. There exist time series of several years from approx. 250 sites. In running waters, temperature is measured at 84 sites, data exists from about 300 sites.

The Department of Environmental Assessment has single measurements or complete profiles from almost all measurements at all sites.

Spatial coverage and resolution

The spatial coverage and resolution is very good.

Temporal resolution

The temporal resolution is very good. The first time series started in 1939.

Statistical properties

The measurements from the eleven lakes were analysed in order to understand how and why different morphology, position, exposure to the wind etc., affect the temperature in a lake. The results are published in Eklund /1988/.

Time schedule

It is important that the temperature measurements follow the seasonal changes at different depths in a lake. All equipment used for sampling should be fitted with some kind of thermometer.

Potential resources

The person/organisation that carries out the measurements of oxygen should be able to measure the temperature at the same time.

Effects on environment

None.

5.8.2 Costs

Temperature measurements can be obtained with very low extra cost if they are made at the same time as other measurements.

Material, special resources

Thermometer.

Time requirements

It is difficult to allocate the cost between different parameters of the sampling procedure. The marginal time required for sampling the temperature is probably only the time it takes to read and record the value from a thermometer.

5.8.3 Conclusions

Temperature is an important parameter for the biology of a water body. It is not likely to be affected by most local human activities, but is very valuable in the modelling of biological processes.

5.9 Sediment transport

Fragmental or clastic mineral particles derived from soil, alluvial and rock materials by processes of erosion, and transported by water, wind, ice, and gravity. Excluded from the definition are vegetation, wood, bacterial and algal slimes, extraneous light-weight artificially made substances such as trash, plastics, flue ash, dyes, and semisolids.

5.9.1 Existing data

SMHI started to measure the sediment transport in Swedish watercourses during the late 60's. The grid of stations comprised, at its largest extent, 35 observation sites. The sites were selected to represent watercourses of different sizes and locations as well as different soil types. The programme was discontinued in 1994. Examples are given in Brandt /1996/.

Spatial coverage and resolution

The spatial coverage is very good, there were observation sites from Övertorneå in the north to Mörrum and Klippan in the south.

Temporal resolution

The discharge was the governing parameter for the sampling frequency in SMHI's programme. This means that samples were taken at higher frequency at times with higher discharge. The reason for this is that the sediment transport might be several magnitudes higher at high discharge than at normal flows.

Statistical properties

Statistics can be obtained from SMHI.

Methods/models used for existing data

SMHI used a depth-integrating sampler developed by Nilsson /1969/.

5.9.2 Methods for data collection

According to Gretener /1994/, the "instruments used to acquire data for estimates of sediment load have to be suited to the conditions in the river under investigation. Consequently, to obtain good quality data the choice of sediment sampler has to be carefully considered, as does the choice of sampling site and sampling frequency. There are a large number of suspended sediment samplers currently in use, since in earlier investigations instruments were developed for each project independently; consequently, a comparison of results from different investigations is very difficult."

World Meteorological Organization has issued a manual on sediment transport measurements. The purpose of this manual was to compile all relevant information on instruments and methods for measuring sediment transport. The attention is focused on those instruments that have proven to be reliable and successful under field conditions. This guide is issued under HOMS /WMO, 1999, www/, an international programme, which Sweden participates in.

Automatic devices do exists, but given the expected nature of the areas under investigation, the cost of such a solution would be far too high.

Under the assumption that the places that will come under consideration for deep-level repositories will be located in areas with mainly smaller watercourses, the method developed by Nilsson /1969/ can be recommended. This method is well suited to Swedish conditions in general. Sampling should take place before and after disturbances are expected, in order to establish background levels. Sampling should take place in conjunction with construction activities and other project-related activities that may affect the stream(s), e.g. heavy transports. It is absolutely necessary to sample the streamflow at the same time as sampling sediments, since the measurement has no value without corresponding flow data.

Background data needs

Good quality hydrological rating curves are helpful in determining the scope of a sampling programme. Measurements before any construction takes place is necessary in order to establish the baseline.

Time schedule

It is very important to measure the yearly extreme flows with high frequency since it is on these occasions that most of the naturally mobilised sediment is transported. As stated above, the time schedules will be determined by the activities in the areas near streams, since intensified sampling should take place whenever disturbances are expected.

Potential resources

Hydroconsult, SMHI, SwedPower AB, other consulting agencies.

Data processing

The samples should be filtered and burned in an oven at 550°C. The remaining weight minus the ash weight of the filter paper(s) is the determined sample content of sediment. This is then used for calculating the sediment transport in weight per volume.

Uncertainty – Risks

The accuracy of the method can not be expected to yield better estimates than ±10%

Effects on environment

Little or no impact.

5.9.3 Costs

Quite high. During intensive work periods sampling has to take place with high frequency. A week of intensive measurements with corresponding laboratory work should cost something in the order of 40 000 SEK. The cost for a single measurement will depend on the distance to be travelled, but should for distances <100 km be in the order of 5 000 SEK. Automatic devices are very expensive but do have the advantage of providing continuous measurements.

Material, special resources

An adequate suspended sediment sampler is needed as well as access to a suitable laboratory with filtering equipment and a satisfactory oven.

Time requirements

See above under costs. The total time needed entirely depends on the site conditions.

5.9.4 Conclusions

The method developed by Nilsson /1969/ is recommended.

6 Discussion

In general, it is obvious that it is not possible to get the complete all-encompassing picture of the amount of existing data until the survey sites are definitely decided upon. Only then, will it be possible to see both which variables are actually relevant, and what data is available for the specific sites. Some information is very narrow in its geographical resolution (range or sample plots), which means that the information might be right on the spot or not, all depending on what sites that are to be surveyed.

Therefore, we suggest that when the survey sites are selected, an additional review is undertaken. This review would assess what variables, and respective data sources and methods that are relevant at the respective site and for the different parts of the project, i.e.:

- The final site selection process.
- The site surveys.
- The EIA-process.
- The monitoring programme.

6.1 Fishery

A thorough knowledge of local and regional conditions is available at the divisions for fishery and/or nature conservation at the county administrative boards. But this is mostly only true for issues related to compliance, such as fishery licenses, permits for aquaculture, fish release permits, information on fish-management associations etc. The county administrative boards also handle subsidiary issues, such as liming and fish management subsidiaries. Other important regional sources of information can be large on-going environmental projects, where relevant studies are being undertaken.

Local sources of information can also sometimes be of importance for this type of assessments. But in general terms, the quality of both the data collection methods used and the statistical precision in these sources are inadequate.

We believe that there do not exist any significant sources of relevant information besides those given in this report.

The existing information on the Variable Fishery, including fish populations, fishery and aquaculture in lakes and rivers is, as stated above, inadequate. This means that new surveys will most likely have to be carried out.

6.2 Biota

The Variable group Biota is a complex group, with its full context of “all living organisms in a given space”. A complete knowledge of this complex concept is impossible, but also unnecessary, to reach in order to establish a useful assessment of the areas concerned. Instead, a limited set of variables that together enable an understanding of the ecology of the areas in concern, would be sufficient.

In this work, we suggest the occurrence of species and habitat types in a general context, together with particular emphasis on key biotopes and red-listed species, as the proper set of variables needed.

It is our opinion that it is neither possible nor particularly relevant to have a full knowledge of all occurring plant species within the areas in question. Looking at vascular plant data from the 5 x 5-km squares in which the deep-level repositories might be placed may be relevant in the site selection process. But later on, as the site surveys and finally the construction work are initiated, having control of the occurring red-listed species (and key biotopes) is sufficient to take the necessary precautionary actions to comply with any relevant requirements.

6.3 Hydrology

The crucial issue is to determine the objective and location of the studies. If the information is needed in order to provide a basis for site selection, many, even most, of the described parameters are of no or very little consequence. If, on the other hand, the sampling programme will be used in order to monitor most environmental parameters before, during and after construction of a deep-level repository at a determined site, then most of these parameters do have a place. It is, however, recommended that a thorough assessment is conducted regarding the importance of the various variables, e.g. answering the simple question: What is important and what is not?

One important word of warning: The existing local data is often extracted/derived from regional data. This makes comparisons between locations within communities impossible, since the data will be the same.

It is important that laboratories contracted for work are certified/accredited by SWEDAC, since this is a guarantee for compatibility with older measurements and Swedish Standards.

Background measurements of the pre-project conditions will form a crucial foundation for coming assessments. This means that it is imperative with high precision.

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