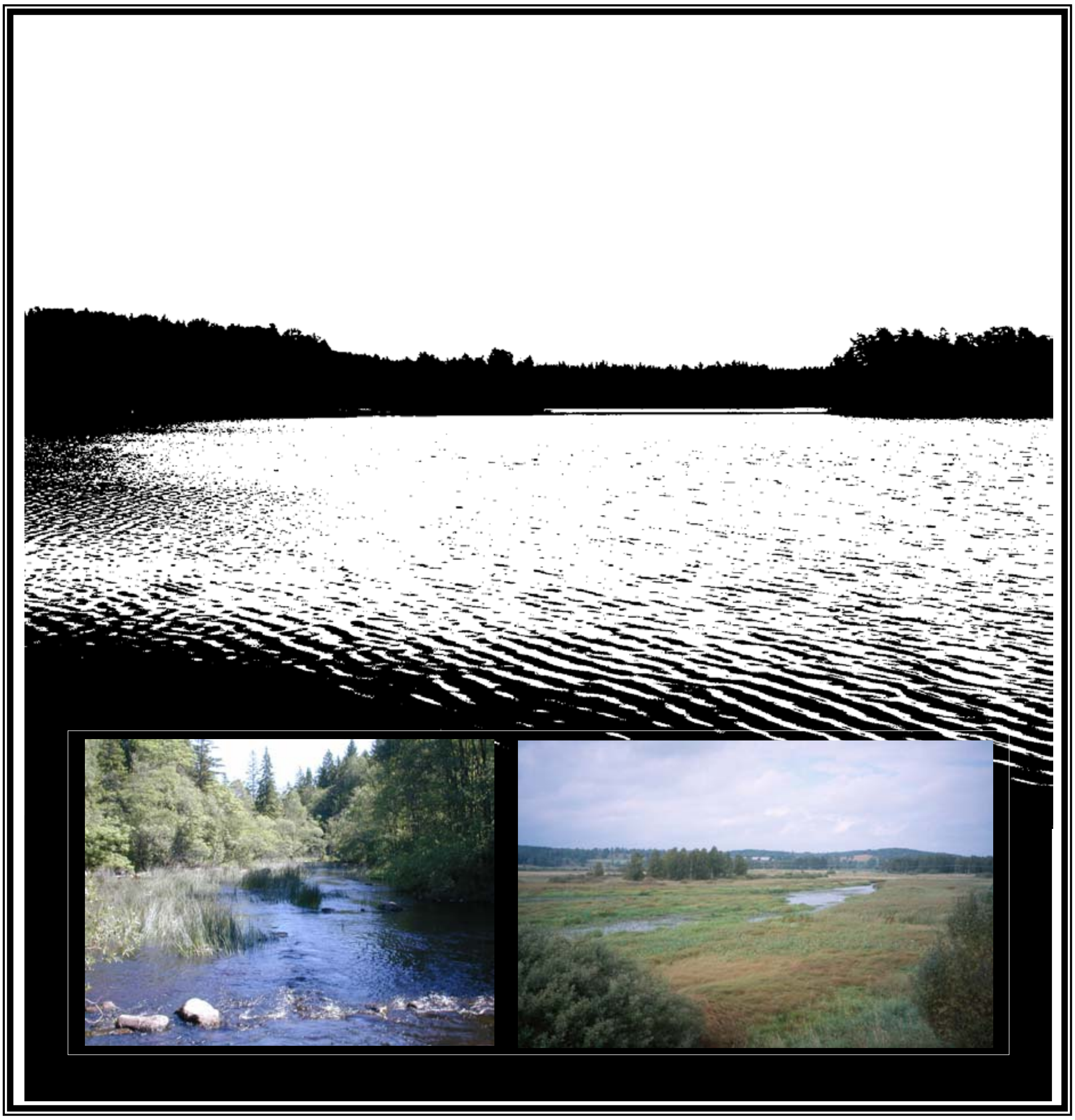
Monitoring of Natura 2000 freshwater habitats

A suggested program for Natura 2000 lakes and watercourses in the County of Jönköping/Sweden



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A suggested program for Natura 2000 lakes and watercourses in the County of Jönköping/Sweden

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Degree project (20 credits) in Environmental Sciences,
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Abstract

In 1992, the EU initialised a concept for the protection of biodiversity by creating a network of valuable habitats called Natura 2000. This is based on the Birds and the Habitats Directive. Sweden as well as the other member states is obliged to protect species and habitats that are included in this network. A monitoring system for the Natura 2000 sites has to be set up and running by 2004 to answer the tasks of the directives.

The aim of this study was to investigate how Natura 2000 freshwater habitats can be monitored on a regional scale in Sweden. Adequate parameters and methods were investigated and a preliminary monitoring program for Natura 2000 lakes and watercourses in the County of Jönköping has been suggested. Next to parameters such as water quality, phytoplankton, and fishes, which are often included in existing monitoring programs, elements as aquatic vegetation, water level and shore structure will get a new importance. Additionally, indicator species will have a very strong meaning for an effective monitoring. Swedish standard methods cover almost all suggested basic parameters; some have to be adapted to the needs for a more extensive monitoring of protected sites. Methods for e.g. structure elements and water level have to be added.

The outcome of this case study shows that there is a high variability between the single sites concerning the conditions, threats, and existing monitoring. Basic information and more frequent monitoring will be necessary in the beginning; especially for the sites that are not subject to running monitoring today. For every site specific objectives have to be formulated, which should be part of the conservation plans and related to the existing monitoring. The results of the monitoring will either have to be set in relation to earlier data or evaluated with help of assessment instruments.

The costs of the suggested monitoring program were calculated for the County of Jönköping. Existing monitoring covers around half of the costs for a basic monitoring program. However, a coordination of existing monitoring programs may help to keep the costs down. There is currently no extra financial support for the monitoring of Natura 2000 sites.

The result of the present work indicates that monitoring of Natura 2000 freshwater habitats can be combined with monitoring programs that are done to fulfil the Water Framework Directive and the National Environmental Objectives.

Sammanfattning

1992 introducerade EU ett koncept för bevarande av biologisk mångfald som kallas Natura 2000. Konceptet är baserat på habitat- och fågeldirektivet. Sverige liksom andra medlemsstater är skyldiga att skydda arter och habitat som ingår i Natura 2000. Ett uppföljningssystem för Natura 2000-områden måste startas upp och vara fungerande senast 2004 så att det svarar upp mot de krav som direktiven ställer.

Syftet med den här studien var att undersöka hur akvatiska naturtyper kan följas upp på regional nivå i Sverige. Lämpliga parametrar och metoder kartlades och ett preliminärt uppföljningsprogram för sjöar och vattendrag inom Natura 2000 i Jönköpings län föreslogs. Förutom parametrar som vattenkvalitet, växtplankton och fisk, vilka ofta ingår i existerande miljöövervakning kommer även makrofyter, vattennivå och strandförhållanden mm att bli viktiga. Dessutom kommer indikatorarter att vara betydelsefulla i ett effektivt uppföljningssystem. Standardmetoderna i Sverige täcker nästan alla föreslagna parametrar; några behöver dock anpassas för att passa in i uppföljningssystemet. Metoder för fysiska förhållanden (t ex bottensubstrat) och vattennivå behöver läggas till.

Denna studie visar att variationen är stor mellan olika Natura 2000-områden avseende tillstånd, hot och existerande miljöövervakning. Insamling av basinformation och mer frekvent miljöövervakning kommer att bli nödvändig under uppföljningssystemets inledningsfas; särskilt för de områden som inte har någon miljöövervakning idag. För varje Natura 2000-område ska målsättningar formuleras, vilka ska ingå i bevarandeplaner och samordnas med existerande miljöövervakning. Resultaten från uppföljningen kommer att behöva utvärderas mha tidigare miljöövervakning, bedömningsgrunder mm. Data från uppföljningen kommer att lagras i en databas.

Kostnaderna för det föreslagna uppföljningsprogrammet beräknades för Jönköpings län. Existerande miljöövervakning täcker ungefär hälften av kostnaderna för ett grundläggande uppföljningsprogram. En samordning med existerande miljöövervakning kan ytterligare bidra till att minska kostnaderna. Det finns idag inte någon extra finansiering tillgänglig för att stödja uppföljningen av Natura 2000-områden.

Resultatet från föreliggande studie indikerar att uppföljning av akvatiska naturtyper kan kombineras med existerande och kommande miljöövervakning för att tillgodose syftena med ramdirektivet för vatten och de svenska miljömålen.

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1. Introduction

In 1992, at the United Nations Conference on Environment and Development in Rio de Janeiro, Brazil, it was agreed on a strategy for sustainable development, which includes two agreements, the Convention on Climate Change and the Convention on Biological Diversity (Convention on Biological Diversity 2002). The later is the first global agreement on the conservation and sustainable use of biological diversity. Over 150 governments signed the document at that conference on biological diversity and since then more than 175 (in total) countries have ratified the agreement (including Sweden and the EU). This treaty establishes three main goals: the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits from the use of genetic resources (Convention on Biological Diversity 2002).

To fulfil the requirements of the Convention on Biological Diversity, and protect biodiversity and natural resources, the European Community (EC) has decided to create a network of (on Community level) protected areas, called Natura 2000. This includes two legal instruments: The "Birds" and "Habitats" Directives (Council Directive 79/409/EC on the conservation of wild birds, and Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora). The Birds Directive came already in force 1979, but the Habitats Directive is rather new (1992) and still in an initiating process. The directives represent a basis for the protection of rare and endangered species and natural habitats. Merging these directives, the EC creates a network of sites, which are of Community importance and protected at Community level. Sites of interest to the EC are habitats whose natural range is very small or has shrunk considerably. The Natura 2000 network will include a representative sample of these habitats and will aim to ensure that the fauna and flora receive sufficient protection to assure their long-term viability (EC 2002).

Natura 2000 are for example habitat types of marine, freshwater, grassland, dune, fen, and forest surroundings. These habitats can be National parks or Nature reserves (or parts of these) or just valuable sites with no special protection status today. The Habitats Directive does not require that the sites have a status of a nature reserve, a national park or similar. Instead, it is up to the member states to only make sure that these sites keep their favourable conservation status. In any case, an environmental impact study will have to be done in relevant cases when a project could have a negative impact on a Natura 2000 site (Art. 6, Habitats Directive).

The implementation process of the Habitats Directive is made in several steps: In the first, all member states were asked to select and suggest areas that are important for the protection of the Natura 2000 species and habitats (proposed Sites of Community Interest, pSCI). In the next step, the EC analyses these suggestions and makes changes. Both steps are behind the time schedule and still going on. After having an approved version of the list, the member states shall in the third step make these Sites of Community Importance (SCI) to Special Areas of Conservation (SAC), finished by June 2004. In the same year, the county administrative boards of Sweden shall have decided the conservation objectives for the sites and started the measures (including the monitoring) that are necessary for the conservation of these areas (SEPA 1997b and 2002a).

The member states shall present a report on the state of the Natura 2000 sites to the EU every six years. These reports shall include information concerning the conservation measures and the evaluation of their impact on the conservation status of the natural habitat types as well as if the ‘favourable conservation status’ has been reached respectively hold (Art. 17, Habitats Directive). In 2006-2007, the second report shall go to the EU and the follow-up system be running.

There have been done (at least) two studies on the implementation of Natura 2000 in Sweden. Söderberg (1998) has been looking on how the Habitats Directive has been seen from a local authority perspective. He showed that in Sweden, the majority of the representatives of the counties believed in 1998 that the possible future effects of the Habitats Directive on nature conservation in their county, on Swedish nature conservation as a whole and on a European conservation level would be negative.

Hedman (2002) showed the problems the county administrative boards had during the task of listing relevant sites for the specific habitat types in their county. The certainty of the choices of sites that belong to a definite habitat type had been to rather high percents (up to 78% for freshwater habitats) ‘very low’ to ‘low’. Within the freshwater habitats, the ‘Watercourses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation’, ‘Natural dystrophic lakes and ponds’, and ‘Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp.’ seemed to be most difficult. Hedman showed also that the counties had been choosing their freshwater sites mostly “mellan tummen och pekfinger” (‘Pi mal Daumen’) and by using different existing material. That the choice of habitats has been based on relatively little knowledge instead of on ‘scientific investigations’ can be a demonstration by the lack of data, monitoring, and investigations on a regional level.

Since the member states have promised to secure that the Natura 2000 sites have a favourable conservation status and also because they have to report on this, monitoring of these sites has to be done. There seems to be a lack of existing monitoring programs and methods for monitoring protected freshwater habitats.

2. Aim

The aim of this project is to study how freshwater habitats, protected by EU law, can be monitored on a regional scale. A suggestion on how the different Natura 2000 lake and watercourse habitats could be monitored in the County of Jönköping will be designed. By this, it will be investigated what general parameters (e.g. phytoplankton, water quality, distribution of macrophyte species) have to be monitored and by what methods they shall be monitored, specifically if they are suitable to determine the conservation status of freshwater habitat types due to the tasks of Natura 2000. Already existing overview lists of parameters for each freshwater habitat type are completed and available methods and monitoring possibilities (using e.g. the Environmental Monitoring Handbook, SEPA 2002i) selected. These generally developed monitoring suggestions for freshwater habitats are applied on Natura 2000 freshwater habitat types in the County of Jönköping. During this, already existing monitoring is considered and compared to the needs, and cost calculations are included. By theoretically applying the suggestions on Natura 2000 sites in the County of Jönköping, the ‘reality’ will show if the suggested systems work and where the emphases is going to be, as well if all parameters are covered. The cost calculations will give useful data for the further discussion of the monitoring due to Natura 2000. Cost estimations will also be made to get an idea of the total (extra) costs and used partly as a basis for prioritising different parameters and methods. The outcomes if this study go into a national seminar on the monitoring of Natura 2000 freshwater habitats in Sweden.

Comments on the report

Because this study has had the aim to be used for the County Administrative Board in Jönköping, the report is partly adapted to this purpose.

To be able to work out parameters and methods, the description of the different habitat types and their individual threats in Sweden has been included. This chapter can be excluded during a reading process. Being aware that the case study, included in the appendix, has a rather large size, it seemed anyhow important to include also this part in the report. The 'discussion' has more the character of a synthesis and includes the conclusions.

3. Monitoring Natura 2000 sites – background

As mentioned above, each member state has to deliver reports on Natura 2000 to the EU every sixth year. These reports shall contain information on conservation measures that have been taken and their effects on the conservation status. Further they shall include the most important results from the monitoring of species and habitats (SEPA 2002b). How these reports are going to look like is still unknown, but the EU basically wants information about how large parts of the Swedish Natura 2000 sites (randomised sample) have a 'favourable conservation status'. The conservation status of a natural habitat will be taken a favourable when 'its natural range and areas it covers within that range are stable or increasing, and the specific structure and functions which are necessary for its long-term maintenance exist for the foreseeable future' (Art. 1e, Habitats Directive). Further, the conservation status of its typical species has to be favourable, which is taken when 'population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats, and the natural range of the species is neither being reduced nor is likely being reduced for the foreseeable future, and there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis' (Art. 1i, Habitats Directive). The need is to initiate a monitoring program, which gives us the knowledge of what is going on in the habitats and, most important, if any – negative – changes occur.

The monitoring of Natura 2000 sites will include two concepts (suggestion of the SEPA/project group):

1) Monitoring on landscape, habitat and species level

The monitoring system has to be designed in a different way for different habitat types and species, depending for example on the covered area, rareness, threats, and ecological characteristics of the site. The objective is to develop follow-up strategies and methods that are optimal from a cost-benefit aspect for different types of protected sites. The monitoring of Natura 2000 habitats can be divided into three levels, as there are the area (landscape level), the habitat level (including structure, functions, succession and dynamics, species density and community), and the species (including also specific indicator species) of one habitat.

Some habitats will only be followed up by efforts on an overall landscape level with large scale highly specified monitoring projects ('surveillance projects') designed to pick up trends across regions and countries (Brown 2001). For example habitat types in the Alps, which are as large as 2 million ha, can be monitored mainly with a new random sampling based program (mostly terrestrial, called NILS) on a landscape level (SEPA 2002b).

For other Natura 2000 habitats, a small-scale monitoring (including habitat and species level) will have to be used. When there is a vascular plant species with three occurrence places in

Sweden, which all are in Natura 2000 sites, a follow-up of the specific places will be the only realistic strategy (SEPA 2002b).

For many habitat types, a combination of the landscape and the habitat level will be most suitable. Additional there will be monitoring of nature conservation measures (before, during, and afterwards), and when characteristics in the surrounding area are important for keeping the favourable conservation status has this to be concerned in the follow-up system too (SEPA 2002b).

This analysis is concentrated on the monitoring of the functions and structures of the habitats. The area will be observed with help of remote sensing and this report will also not focus on the monitoring of Natura 2000 annex-species. In some cases they are mentioned though. The monitoring due to conservation measures will depend very much on the actual situation and is also not considered here.

2) Monitoring on basic and supplementary level

The monitoring of Natura 2000 sites can be done on two levels, a basic and a supplementary level. The **basic level** indicates a minimum-level for monitoring the sites and contains a continuously running program, where the frequencies can be adapted to the main groups of habitats. This level can be described as an extensive monitoring system, which is able to quickly detect indications for changes that can threaten the favourable conservation status of species and habitats in the identified areas. The data from the basic level shall give foundations for assessing when the supplementary level is needed. When the conservation status for a habitat or a species is assessed to be unfavourable, or when protection measures with the direct aim of keeping or restoring the favourable conservation status are carried out (also to follow up the consequences afterwards), additional monitoring on a **supplementary level** is needed. Other reasons for additional monitoring can be for example when surveillance or planning shows impact in or near the site (SEPA 2002b). The follow-up on supplementary level will surely vary considerably in consideration to frequency, methods, prove net (work), ‘available money’, etc.

Practical issues of monitoring Natura 2000 sites in Sweden

Monitoring of protected areas in Sweden needs to develop and change to be able to answer EU-requirements. To organise the development of national monitoring of Natura 2000 habitats in Sweden, a project, called ‘Methods for follow-up and monitoring of Natura 2000’ (‘Metoder för uppföljning och övervakning av Natura 2000’), has been initialised by the Swedish Environmental Protection Agency (SEPA). The SEPA is the central responsible authority for environmental questions in Sweden. Its task is among others to support and give standards for the follow up of nature protection administration and environmental monitoring (SEPA/Swedish Government). The county administrative boards and the Swedish Species Information Centre (ArtDatabanken, national responsible institution for the knowledge about nationally red listed species) are also included in this project (SEPA/Swedish Government). The aim is to develop strategies and standard methods, which will make it possible to give an operative follow-up of the conservation status in Natura 2000 areas and for how the information from the national and regional environmental monitoring program can be used (SEPA 2002g).

Sweden has been divided in three parts: the southern part will work with culture landscape habitats, the mid part with freshwater habitats, and the northern part with forest habitats. Each part has an administration that is held responsible for the development of management and monitoring plans for these habitats and plans for the future of the project. The Jönköping County Administrative Board will be responsible for the freshwater habitats, including wetlands. In October 2002 the Mid-group presented its suggestions and plans for the future of the project on monitoring the freshwater habitats in a national seminar to which the administrations of the other parts were also invited. This report was a contribution to this seminar.

Starting points and underlying working aims for the project are (SEPA 2002g):
- Requirement for the follow-up and reporting due to the Birds and Habitats Directives (which is/will be incorporated in the Environmental Code). With the next reporting date shall a national follow-up system be going on and has begun to produce relevant information;
- There is a need for follow-up of the status in all types of protected areas;
- Overall task of environmental monitoring to produce foundations to describe the status and the trends of the biological diversity regionally and for the whole country;
- The ongoing development of the follow-up system for national and regional environmental objectives.

The follow-up system shall be formed in a way that answers the tasks of the EU-Directives and also contributes national needs. For this reason, follow-up of objectives in regional protection, Natura 2000 and landscape (overall) monitoring in environmental monitoring shall be coordinated.
The tasks of the Swedish Environmental Protection Agency are to (SEPA 2002b):
- Co-ordinate environmental protection work (inclusive monitoring);
- Follow-up of the result of nature protection work;
- Produce foundation for national reports;
- Coordinate methods.

The tasks of the county administrative boards are:
- Planning and carrying out of the nature protection measures;
- Coordination and drift of regional environmental monitoring.

The follow-up system for habitats and species shall be coordinated as much as possible on the overall habitat types. In the same way shall be tried to work with a suitable classification of groups of species with similar habitat demands or population dynamics (or ‘sensitiveness’).

Financial issues of the monitoring

The LIFE fund (EC, Council Regulation 1973/92) was implemented at the same time as the Habitats Directive. Its overall objective is to promote the implementation of Community policy and legislation in the field of the environment. One of the priority tasks is the protection of nature and therefore specifically to help to finance projects that work towards and stimulate the implementation of the Habitats and Birds Directive. It supports to finance measures that are done directly for the conservation of Natura 2000 species and maintaining and restoring Natura 2000 habitats (Sunyer & Manteiga 1998). However, LIFE will only co-finance conservation measures and it is obviously not meant for financing running monitoring programs.

Concerning specifically the finance of the monitoring of Natura 2000 sites in Sweden, the subsidy for environmental monitoring, together with funds for the follow up of other subsidies, is relevant for the implementation of the monitoring required by article 11 of the Habitats Directive (SEPA/Swedish Government). But the final financing is not solved yet.

3.1. Natura 2000 and the Water Framework Directive

The overall monitoring of freshwater habitats in the EU will not only have to be done for the Natura 2000 network, the Water Framework Directive (WFD, 2000/60/EC) will also put the task of monitoring lakes and watercourses (between other water issues) to the member states. This directive is supposed to be the basis of the water strategy of the European Union. It shall bring an improvement in the sustainable and integrated management of the water resources, and all types and uses of water are included. The water management will be based on river basin districts and the aim is to achieve 'good ecology status' of all waters (Article 4, WFD).

Next to the tasks for all water bodies in a catchment area, the WFD names additionally specifically measures for protected sites (Article 4: Environmental objectives). The river basin management plans (Annex VII) shall - between others - include registration of protected areas, a map of the monitoring networks established and a presentation in map form of the results of the monitoring programmes carried out under those provisions for the status of protected areas, and a list of the environmental objectives for protected areas. The register shall include all areas lying within each river basin district that has been decided as requiring special protection under specific community legislation for the conservation of habitats and species directly depending on water (Article 6: Register of Protected Areas).

The member states shall establish monitoring programmes to get a good overview of the water status within each River Basin District. This monitoring includes the ecological and chemical status of surface water, groundwater and water bodies in protected areas. It is dealt up into several parts.

- *Surveillance monitoring* shall give information about the general surface water status in each catchment area. All biological, hydromorphological and physical-chemical factors as well as discharged polluting substances shall be measured every sixth year with a selection of stations, which give a representative picture of each catchment area. These stations are the ones which represent large flows and volumes (large watercourses, lakes and sources of water supply), but also water bodies crossing country borders shall be included.

- *Operational monitoring* shall be done where there is the risk that the environmental objective will not be reached as well as where prioritised substances are discharged. All water-areas with considerable influence by point sources and a selection of areas with diffuse respectively hydromorphological influences shall be included. Biological factors that are most sensitive against anthropogenic influences, prioritised substances that are discharged in considerably amounts, and sensitive hydromorphological factors are monitored.

- *Investigative monitoring* is used between others for unknown influence and unintentional polluting incidents wherefore the need for single member states cannot be decided in forehand.

- *Monitoring of protected areas* includes surface-water that is used for outtake of drinking water and that gives more than 100 m^3/day, and water areas with protected habitats (Natura 2000) and protected species.

For protected areas as Natura 2000, the basic programs for the river basins shall be supplemented by the tasks of the specific protection legislation. The lakes and watercourses shall be included within the operational monitoring program, when there is the risk that they fail to meet their environmental objectives. This will be decided on the basis of the impact assessment and the surveillance monitoring. Then, monitoring shall be carried out to assess the impact of the pressures on these waters and, where necessary, changes resulting from the measures. Monitoring shall continue until the areas satisfy the water-related requirements of the legislation under which they are designated (as e.g. Habitats Directive) and meet their objectives (under Article 4).

The monitoring programs of the WFD shall be operational by the end of 2006. Technical specifications and standardised methods for analysis and monitoring of water status have still to be determined (WFD, Annex V, Surface Water Status).

3.2. Natura 2000 and the National Environmental Objectives

The Swedish Environmental Code's ('Miljöbalken', Swedish Government 1990) overall aim is 'sustainable development', which is formulated more precisely in the fifteen Environmental Objectives (Swedish Government 1997). These objectives describe what quality and state of Sweden's environment and natural and cultural resources are ecological sustainable in the long run (Swedish Environmental Objectives Council 2002). They cover all environmental questions, inclusive water. The work with Natura 2000 will be coupled with the work on the Environmental Objectives, for the lakes and watercourses especially with the one called 'Flourishing Lakes and Streams'. This objective says that 'lakes and watercourses must be ecologically sustainable and their great variety of habitats must be preserved. Natural production capacity, biological diversity, cultural values and the environment's ecological and water-regulating function must be preserved at the same time as recreational values are to be safeguarded' (Swedish Government 1997). It interacts with many of the other objectives as 'Sustainable Forests', 'A Varied Agricultural Landscape', 'A Good Built Environment', and 'A Non-Toxic Environment'.

The Swedish Environmental Objectives Council (2002) presented in a report how the Environmental Quality Objectives have been met until today and what the country is doing to reach them. For the Environmental Objective 'Flourishing Lakes and Streams' they emphasise the point that the conservation of the freshwater habitats has been strongly developed due to the work for the network Natura 2000 program of the EU.

The objective is divided into sectoral objectives, where the aims are more specified. The formulated outcomes and interim targets will require continuously monitoring of the lakes and watercourses due to the follow up and reporting needs (SEPA 2002h). For example, one of the regional objectives in the County of Jönköping in following up of the national Environmental Objectives is that pH shall not be lower than 6,0 and alkalinity shall not be below 0,05 mek/l in lakes and watercourses (Jönköping County Administrative Board 2000c). Monitoring has to be done for the follow-up of the Environmental Objectives, not only to be ably to see if the qualitative objectives are (going to be) reached, but it has to be known how the conditions in the lakes and watercourses change, if there are new threats, etc. To show parameters being useful for the monitoring due to the needs of the Environmental Objectives, the example of Lake Vättern and its monitoring program is used (table 1).

Table 1. *Environmental Objectives and monitoring parameters, example of Lake Vättern (Vätternvårdsförbund 2001)*

Environmental objective	***Relevant monitoring types***
Flourishing Lakes and Streams	Echo-counting of pelagic fish, gillnet fishing (fish investigations, breeding birds inventory, investigations of threatened/rare species, monitoring of glacial relicts)
Zero Eutrophication	Water quality in lakes and the tributaries, phytoplankton, zooplankton, benthic-fauna, vegetation, (primary production, paleoreconstruction)
A Non-Toxic Environment	Toxic substances, benthic fauna, (sediment-chemistry, screening)
Natural Acidification only	Water quality on lakes and the tributaries, precipitation chemistry, fish-”reproduction” in the tributaries, (paleoreconstruction)
Reduced Climate Impact	Phyto- and Zooplankton, temperature and water quality, fish recruitment/catch (investigations of lake morphology, erosion, ice, etc., paleoreconstruction)
Indirectly: Good-Quality Groundwater, Thriving Wetlands	

Effects of the Environmental Objective are supposed to be better drinking water, better conditions in lakes and streams supporting for example fishing and tourism. Further, it could reduce costs due to soil erosion, landslides and flooding. On the other hand, protection, management, and monitoring have their costs. The economical concept for measures concerning the Environmental Objectives is to try to involve everything in already existing organisation. This includes for example the monitoring of lakes and watercourses. Data of existing monitoring programs will be used wherever possible and in necessary cases the measures will be adapted to the needs of the follow-up of the Environmental Objectives.

The monitoring should be coordinated with the monitoring due to Natura 2000 (SEPA 2002f).

4. The County of Jönköping

The County of Jönköping (around 328 000 inhabitants) lies in the Swedish landscape called ‘Småland’ and is 10 475 km^2 large, covering 2,5% of Sweden’s area. It is situated on the Southern Swedish Highlands and more than half of the area lies higher than 200 m above sea level. The lake Vättern (1900 km^2) makes an interruption in the highlands and the lowest (land-) point of the county is at its surface, 88 m above sea level. The land is covered by around 63% of forest. These forests are dominated by spruce, with a few leaf trees. Deciduous forest can mainly be found in the southern part of the county. Between the forests lie small agricultural areas (around 13% of the area), mires (bogs or mosses, 7%), lakes and watercourses. (Jönköping County Administrative Board 1995a and 2002a)

Climate

Since the dominating wind direction is southwest, damp air is forced to rise up at the Southern Swedish Highlands and much higher rainfalls are found in the western parts of the county than in the eastern parts. The precipitation rate varies between 500 (north-east) and 950 (south-west) mm/year. Due to the County’s position on a high level, it is rather cold. The average temperature per year varies between 5,0ºC (highest altitude) and 6,5ºC (lowest altitude). The climate allows a vegetation period of 170-220 days. (Jönköping County Administrative Board 1995a and 2002a)

Geology/Bedrock/Soil

The largest part of the County is of primary rock, generally said: granite in the eastern and gneiss in the western part. The Transscandinanavian igneous belt, consisting of granitoids and associated porphyries, was formed between 1800 and 1650 million years ago. It stretches from Småland through Värmland and western Dalarna (where it is partly covered) and then continues under the Caledonian mountain chain up to northern Scandinavia. Southwest of this belt follows the southwestern gneiss province, formed between 1700 and 900 million years ago. It is divided by deformation zones into several north-south-trending segments (Swedish Museum of Natural History 2002). The edge between the granite and gneiss parts is built of a protogine zone, which stretches from Northern Scania through the County of Jönköping up to Värmland. Younger bedrock can be found around Lake Vättern and in a smaller area in Nässjö municipality. The structure of the landscape in the County of Jönköping has been especially in the western part formed over during the ice ages, where many different glacial structures, as e.g. esker with parallel ridges, drumlins, and terraces, were formed. The county's soil is dominated by moraine, which is relatively acid, apart from e.g. the northern parts of the county, where the moraines are formed by calcium rich bedrock of Östergötland. (Jönköping County Administrative Board 1995a)

Lakes and watercourses

The County of Jönköping has 2359 lakes, of which most ones have a smaller area than 0,1 km^2. They were mainly formed by glacier activities, shaping the bedrock and transporting and depositing bedrock material in an uneven relief (Uppsala University 1978). However, the lakes in the eastern part of the county form the structure of geological processes long time ago. The lakes cover about 8% of the total county area. Sixteen lakes exceed an area of 10 km^2. The largest one is Lake Vättern (a former bay of the sea), which is 128 m deep (the bottom is 31 m below sea level), and has many rare species, including Sweden's southernmost *Thymallus thymallus* (Grayling/Harr/Äsche) population. It is Sweden's second largest lake and has a strong importance, as it is for example a drinking water resources for 300 000 people. In this and other oligotrophic lakes relicts from the ice age, like *Salvelinus umbla* (only Swedish name: Storröding), *Myoxocephalus quadricornis* (Fourhorn sculpin/Hornsimpa/Vierhorniger Seeskorpion) and several crustaceans are found. (Jönköping County Administrative Board 1995a and 2002a)

Most of the watercourses in the county are small nutrient poor brooks that flow through lake-rich forests. More nutrient rich watercourses are found in the agricultural parts, not only due to human activities, but also because this agriculture is situated on the most fertile soils. Humic particles give the watercourses a brownish colour. The watercourses discharge mainly through four large catchment areas as well to the Baltic Sea as to the Kattegatt/Skagerak. The catchment areas are Motala stream with Lake Vättern and River Svartån, River Emån, River Lagan and River Nissan; smaller ones are River Tidan, River Mörrumsån, River Helgeån, and River Ätran. (Jönköping County Administrative Board 1995a and 2002a)

Flora and Fauna

Many of the in Sweden threatened plant species *Eleogiton fluitans* (Floating Club-rush/Flytsäv/Flutende Moorbinse), *Apium inundatum* (Lesser Marshwort/Krypfloka/Flutender Sellerie), *Deschampsia setacea* (Bog Hair-grass/Sjötåtel/Borst-Schmiele), *Pilularia globulifera* (Pillwort/Klotgräs/Pillenfarn) and *Elatine hexandra* (Six-stamened Waterwort/ skaftslamkrypa/Sechsmänniger Tännel) can be found in the county's freshwater habitats. (Jönköping County Administrative Board 1995a)

Further, there can be found a strongly threatened fish species, *Coregonus trybomi* (Lake Fegen), which is found only in a few lakes in the world. Other species, which are special for the county's watercourses are *Margaritifera margaritifera* (Freshwater pearl mussel/Flodpärlmussla/Flussperlmuschel), *Salmo trutta* (Trout/Öring/Forelle) and *Astacus*

astacus (Broad-fingered Crayfish/Flodkräfta/Europäischer Flusskrebs). The freshwater pearl mussel is found in single places in the water systems of the rivers Nissan, Emån and Svartån in nutrient poor running waters with gravel-, stone- or sandy bottom. In the county can be found six watercourses where the pearl mussel propagates, what is very rare in Southern Sweden. The freshwater pearl mussel depends e.g. on trout for its reproduction, and it is very sensible for any kind of changes in its environment. The stream living trout is found on many places in the county's watercourses, thereby lake living trout is very rare. Trout is sensitive to acidifying processes and needs relatively clean water with high oxygen. The broad-fingered crayfish has disappeared from many places in the county due to a parasitic mould, acidification, and the introduction of *Pacifastacus leniusculus* (Signal crayfish/Signalkräfta/Signalkrebs). The Signal Crayfish appears in almost all water systems nowadays. (Jönköping County Administrative Board 1995a)

Many of the European breeding places of *Pandion haeliatos* (Osprey/Fiskjuse/Fischadler) and *Gavia arctica* (Black-throated diver/Storlom/Prachttaucher) are found in the county. Osprey breeds in the tops of pine trees in connection to open waters, feeding only on fish. The black-throated diver breeds in nutrient poor lakes, which are very sensitive to acid precipitation. (Jönköping County Administrative Board 1995a)

In the county can further be found *Lutra lutra* (Otter/Utter/Otter) in a larger surrounding on the Southern Swedish highland but even in several other smaller areas. Otter favours waters with good access to cyprinids the whole year round where it can undisturbed rest and raise up its young. (Föreningen Rädda Uttern i Småland 1995)

A number of bat species depend on freshwater habitats (as *Myotis daubentonii*).

Threats to the lakes and watercourses
The nutrient- and calcium oxide-poor circumstances found in large areas of the county cause a high sensibility for pollution and acidification. Acidification is the largest environmental problem in the County of Jönköping and not affected lakes and watercourses are rare. Even though the loads of sulphur by precipitation have decreased by half from the end of the eighties (Jönköping County Administrative Board 1995b), it still exceeds the critical load that the soil can bear and it has not led to better conditions in the soil water quality (Jönköping County Administrative Board 2000d). Around half of the lakes and watercourses lie in the southern and western parts of the county, which are sensitive for acidification. There, the soil is only a thin layer and calcium poor. Additionally, the precipitation rate is high and these parts lie closer to the winds (bringing pollutants with them) coming from Middle Europe. Acidification causes that e.g. many acidification sensitive species of mayflies and snails, as well as crayfish, freshwater pearl mussel, salmon trout, minnow and roach can not survive in these freshwater habitats any longer. These waters become therefore very species poor. Acidification causes also high concentration of metals in the water and therefore e.g. high amounts of mercury in fish. To protect the water, many lakes, wetlands and watercourses in the county are limed (Jönköping County Administrative Board 2000d).

Besides acidification, other threats are for example the high amounts of nutrients from the community and agriculture, which cause eutrophication of waters. Agriculture and forestry cause hydrological interventions (e.g. ditching, clear-cutting) and regulation of the water flow. This is a threat to the biodiversity especially in small watercourses. Further, environmental pollutants (as e.g. pesticides), theirs effects are not all known yet, can cause problems in any kind of freshwater habitat. Sources are many, as industry, traffic, households, agriculture, and forestry, and some of these substances are transported over long ways.

County/The County Administrative Board
Sweden is divided into 21 counties. County administrative boards are a part of the Swedish governmental system and work primarily as the central government's representative in a county. An important task is to coordinate government interests and to ensure that national goals are implemented. One of the primary tasks is to act as an administering authority for e.g. the issuing of permissions and the distribution of EU-subsidies. County administrative boards supervise that laws and regulations are followed, for example within the environmental field, in social and rescue services (Jönköping County Administrative Board 2002a).

5. Natura 2000 freshwater habitat types (in the County of Jönköping)

The network Natura 2000 contains many different habitat types and is divided into several biogeographical regions. Sweden lies mainly in the boreal region and only a small part of Scania is within the continental region. The County of Jönköping is totally within the boreal region. Of the categories 'standing water' and 'running water' there are eight freshwater habitat types in total in Sweden (SEPA 1997a). The County of Jönköping includes seven of them (see table 2), which are presented in the following part.

Table 2. *Freshwater habitats in the boreal region (the* ***bold expressions*** *is used as short forms in this report)*

	Number of sites in Sweden (Swedish Environmental Objectives Council 2002)	***Number of sites in the County of Jönköping***
Lakes		
Oligotrophic waters containing very few minerals of sandy plains (Littorelletalia uniflorae)	18	4 (22,2%)
Oligotrophic to mesotrophic standing waters with vegetation of the littorelletea uniflorae and/or of the Isoeto-Nanojuncetea	206	19 (9,2%)
Hard oligo-mesotrophic waters with benthic vegetation of Chara spp.	32	1 (3,1%)
Natural **eutrophic lakes** with Magnopotamion or Hydrocharition-type vegetation	86	1 (1,2%)
Natural **dystrophic lakes and ponds**	277	12 (4,3%)
Watercourses		
Fennoscandian natural rivers	125	1 (0,8%)
Alpine rivers and the herbaceous vegetation along their banks	87	0
Watercourses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation	98	16 (16,3%)

5.1. Lake types

In the following, the different lake types are described, with special consideration to their occurrence in Sweden. Since the threats can be very similar for the diferent lake types, the most common threats are described here and at the single descriptions, more specific threats are named.

- Regulation/lowering the water level of a lake causes unnatural water level fluctuations, over-damming and/or unnatural low water level, which can cause on the other hand erosion, mudding and/or revegetation of the strand zone. Regulations provide often migration barriers.
- Introduction of non-native species or fish populations can change the competition behaviour, spread infects and/or cause genetic contamination.
- Domestic discharge/Discharge of pollutants from point sources, e.g. sewage, industry, pits or other activities.
- Roads/railroads; building, maintenance and traffic can cause turbidity and discharge of environmental dangerous substances into the ditches and watercourses upstream oligotrophic lakes. Bridges and conduits over in- and outflow can cause migration barriers.

5.1.1. Oligotrophic waters containing very few minerals of sandy plains (Littorelletalia uniflorae) (3110)

Oligotrofa mineralfattiga sjöar i slättområden

This habitat type is characterised by shallow oligotrophic water, which contains only few minerals and is base poor (slight acid to neutral). The clear water has low anthropogenic loads (humus, acidifying substances, particles, nutrients, and pollutants). It can appear to have a wide spectrum of e.g. pH, watercolour, and total phosphorous. Oligotrophic clear water lakes are often found in areas with (glacifluvial) gravel or sand sediments in whole Sweden, many times in connection with esker/delta formations from the ice age. On these oligotrophic soils of lake and pond banks (sometimes on peaty soils) grows freshwater to amphibious low perennial vegetation, which belongs to the *Littorelletalia uniflorae* order. Isoetids, low rosette leaved plants, are characteristic for this kind of lake and favoured by clear water. The vegetation consists of one or more zones, dominated by *Littorella*, *Lobelia dortmanna* or *Isoetes*. Following a zone with *Isoetes lacustris* in the deeper water comes regularly closest to the strand a zone with *Lobelia dortmanna*. On the strand grows often *Phragmites australis* or *Equisetum fluviatile*. (EC 1999; SEPA 2001d; Airaksinen & Karttunen 1999)

Preconditions for a good conservation status are for example natural water level fluctuations, undisturbed hydrology, free moving possibilities to the connected water systems, a natural species composition without influence of non-native species (introduction of fish stocks), and natural surroundings with intact strand wetlands and strand forests (SEPA 2001d). The typical species can be seen in table 3.

Table 3. *Typical species for oligotrophic waters containing very few minerals of sandy plains (Littorelletalia uniflorae) in Sweden (Swedish Species Information Centre 2002); 1: Natura 2000 species (Habitats Directive, Annex 2), 2: red-listed species in Sweden (Swedish Species Information Centre 2002)*

Vegetation	
Lobelia dortmanna	(Water Lobelia/Notblomster/Wasserlobelie)
Isoetes lacustris	(Quillwort/Styvt braxengräs/See-Brachsenkraut)
Littorella uniflora	(Shoreweed/Strandpryl/Strandling)
Potamogeton polygonifolius	(Bog pondweed/Bäcksnate/Knöterich-Laichkraut)
Isoetes echinospora	(SpringQuillwort/Vekt braxengräs/Stachelsporiges Brachsenkraut)
Subularia aquatica	(Awlwort/Sylört/Pfriemenkresse)
Fontinalis spp.	
Birds	
Podiceps auritus[1,2]	(Slavonian Grebe/Svarthakedopping/Ohrentaucher)
Amphibians	
Triturus vulgaris	(Common Newt/Mindre vattensalamander/Teichmolch)

Specific threats (SEPA 2001d):

- Forestry; the submerged vegetation, characteristic for clear water lakes and consisting of isoetids, is depending on the fact that the sunlight can reach through the water column. These lakes are therefore especially sensitive to high loads of humic substances and nutrients, which both, in different ways, affect the Secchi depth in the water negatively. Forestry activities in the catchment area can cause high loads of humic substances, turbidity and mud to the vegetation and deep bottom. Cutting off riparian forest changes the hydrology and structure of the strand zone and causes high loads of larger organic matter. Many of the characteristic species for oligotrophic waters are depending on riparian forest as a biotope. Building forest roads/passages over in- or outflows can cause migration barriers for freshwater organisms.
- Agriculture on the lakes sandy, relatively nutrient-poor surroundings can cause leakage of fertilisers (nutrients) and pesticides and increases the load of turbid substances. Extensive agriculture can often help to hold the pasture and strand meadows open, though (good for some rare species).
- Exploitation of the strand areas. The oligotrophic clear water lakes are often aesthetically pleasing, which can cause a strong exploitation pressure.
- Liming of wetlands in the surrounding areas changes the conditions for native species.
- Acidification – the oligotrophic, mineral poor clear water lakes have often low buffering capacity against acidifying substances. Anthropogenic pollution can contain an unnatural lowering of the pH in the water.
- Next to eutrophication and acidification, humic substances and suspended material from drainage of mires and forests are the main threats to this type of lakes. The loads can cause dystrophication of the water. Widely distributed submersed moss populations (*Sphagnum sp*, *Chiloscyphus polyanthos*) are in general a sign for an ongoing acidifying process or a dystrophy development of the water system. (Airaksinen & Karttunen 1999)

Existence: Belgium, Denmark, France, Germany, Great Britain, Greece, Ireland, Italy, Netherlands, Portugal, Spain, and boreal regions in Finland and Sweden. (Airaksinen & Karttunen 1999)

5.1.2. Oligotrophic to mesotrophic standing waters with vegetation of the Littorelletea uniflorae and/or of the Isoeto-Nanojuncetea (3130)

Oligo-mesotrofa sjöar med strandpryl, braxengräs eller annuell vegetation på exponerade stränder

This habitat type is difficult to distinguish from 3110 (Oligotrophic waters containing very few minerals of sandy plains (Littorelletalia uniflorae)). It is characterised by natural nutrient poor (slight acid to neutral) or slight nutrient rich (slight basic) and relatively clear water with low grade of anthropogenic loads (humus, acidifying substances, particles, nutrients, and pollutants). The water can have a wide spectrum of e.g. pH, watercolour, and total phosphorous. The water systems can show strong water level changes. Characteristic plant species of this habitat type are generally small ephemerophytes. There can be found two units that can grow together in close association or separately. One is freshwater to amphibious perennial vegetation, oligotrophic to mesotrophic, of lake, pond and pool banks and water-land interfaces belonging to the *Littorelletea uniflorae* order. The other one is amphibious short annual vegetation (*Isoeto-Nanojuncetea* class), pioneer of land interface zones of lakes, pools and ponds with nutrient poor soils, or which grows during periodic drying of these standing waters. (EC 1999; SEPA 2001d)

Preconditions for a favourable conservation status are for example natural, often strong water level fluctuations, undisturbed hydrology, free moving possibilities in/to the connected water systems, a natural species composition that is typical for this habitat type without non-native species (fishes), natural surroundings with intact strand wetlands, strand forests and possible even grassed strand meadows (that should be kept). The water systems with flat strands and/or strand grazing are relatively species rich (SEPA 2001d), see table 4 for typical species in Sweden.

Table 4. *Typical species for oligotrophic to mesotrophic standing waters with vegetation of the Littorelletea uniflorae and/or of the Isoeto-Nanojuncetea iin Sweden (Swedish Species Information Centre 2002); 1: Natura 2000 species (Habitats Directive, Annex 2), 2: red-listed species in Sweden (Swedish Species Information Centre 2002)*

Vegetation	
Potamogeton polygonifolius	(Bog Pondweed/Bäcksnate/Knöterich-Laichkraut)
Pilularia globulifera[2]	(Pillwort/Klotgräs/Pillenfarn)
and/or	
Isoetes lacustris	(Quillwort/Styvt braxengräs/See-Brachsenkraut)
Isoetes echinospora	(Spring Quillwort/Vekt Braxengräs/Stachelsporiges Brachsenkraut)
Ranunculus reptans	(Creeping Spearwort/Strandranunkel/Ufer-Hahnenfuss)
Elatine triandra	(…/Tretalig slamkrypa/Dreimänniger Tännel)
Elatine hydropiper	(Eight-stamened Waterwort/Slamkrypa/Wasserpfeffer-Tännel)
Birds	
Gavia arctica[1]	(Black-throated Diver/Storlom/Prachttaucher)
Actitis hypoleucos	(Common Sandpiper/Drillsnäppa/Flußuferläufer)
Larus canus	(Common Gull/Fiskmås/Sturmmöwe)
Bucephala clangula	(Goldeneye/Knipa/Schellente)
Mergus merganser	(Goosander/Storskrake/Gänsesäger)
Sterna hirundo[1]	(Common Tern/Fisktärna/Flußseeschwalbe)
Fishes	
Salmo trutta	(Trout/Öring/Forelle)
Salvelinus umbla[2]	(Storröding)
Salvelinus alpinus	(Arctic Char/Fjällröding/Seesaibling)
Thymallus thymallus	(Grayling/Harr/Äsche)
Coregonus	(Whitefish/Sik/Maräne)
Silurus glanis	(Wels catfish/Mal/Wels)
Oncocottus quadricornis[2]	(Fourhorned Sculpin/Hornsimpa/Vierhorniger Seeskorpion)
Aspius aspius[1,2]	(Asp/Asp/Rapfen)

Specific threats (SEPA 2001d):

Lakes belonging to this type are influenced by humification, eutrophication, acidification and regulation. The single sites most influencing factors is probably the regulation of the water level, since revegetation or mudding of the strand zone influences the conditions for the characteristically vegetation negatively.

- Forestry in the catchment area, with cutting and drainage, can cause increased loads of humic substances, turbidity and mudding to the vegetation and deep bottom. Cutting of strand forest changes the hydrology and structure of the strand zone and increases the amount of larger organic matter in the lake. Many of the characteristic species for oligotrophic waters are depending on strand forests as a biotope. Building forest roads/passages over in- and outflows can cause migration barriers.
- Agriculture in the tributary areas: drainage and regular cleaning of ditches can cause turbidity. Intensive cultivation in the lakes and the tributary strand zones risks causing leakage of fertilisers (nutrients) and pesticides. Extensive agriculture can often help to hold the pasture and strand meadows open, though.
- Acidification. Oligo-mesotrophic lakes have often low pH-buffering capacity. Anthropogenic pollution can contain an unnatural lowering of the pH in the water.

- Liming of wetlands in the surrounding areas changes the conditions for native species.

Existence: Belgium, Finland, France, Germany, Great Britain, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, and Sweden. (Airaksinen & Karttunen 1999)

5.1.3. Hard oligo-mesotrophic waters with benthic vegetation of Chara spp. (3140)

Kalkrika oligo-mesotrofa sjöar vatten med bentiska kransalger

This is a rather rare lake type compared to the others included in the Natura 2000 network in Sweden. These lakes and pools have waters fairly rich in dissolved bases (pH often 6-7) or with mostly blue to greenish, very clear waters poor (to moderate) in nutrients and base-rich (pH often >7.5). There can be a wide spectrum of e.g. the amount of calcium oxide, nutrients or Secchi depth in the water. The distribution of this habitat type follows the distribution of calcium oxide rich rock and therefore it is not very common in the County of Jönköping. The bottoms of these unpolluted water bodies are covered with algae carpets (*Chara* and *Nitella*). In the Boreal region this habitat type includes small calcareous-rich oligo-mesotrophic gyttja pools with dense *Chara* (dominating species is *C. strigosa*) carpets, often surrounded by various eutrophic fens and pine bogs. (SEPA 2001d; EC 1999)

Preconditions for a favourable conservation status are for example a natural species composition without non-native species, natural water level fluctuations, and undisturbed hydrology. Lakes and small waters of this type in agricultural areas are often influenced by lowering of the water level or regulations. No or only little influence of diffuse pollution, run-off of the surrounding soils or point emissions should occur. The natural strand zones should be without direct influence of drainage, agriculture, (forest) cutting, or buildings (SEPA 2001d). For typical species in Sweden, see table 5.

Table 5. *Typical species for hard oligo-mesotrophic waters with benthic vegetation of Chara spp. in Sweden (Swedish Species Information Centre 2002); 2: includes several red-listed species in Sweden (Swedish Species Information Centre 2002)*

Vegetation	
Najas marina	(Holly-leaved Naiad/Havsnajas/Grosses Nixkraut)
Potamogeton filiformis	(Slender-leaved Pondweed/Trådnate/Faden-Laichkraut)
Chara spp.[2]	
Nitella spp.[2]	

Specific threats (SEPA 2001d):

This habitat type is a biotope for many of the in Sweden red-listed *Chara* species.

- Leakage of nutrients from the surrounded agricultural areas increases the risk for eutrophication. *Chara*, which characterises this lake type, are more sensible then many other submersed plants for increased shadowing by phytoplankton and Periphyton and disappear in a very early phase of an eutrophication process.
- Intensive crop cultivation in the strand zone increases the risk for erosion and leakage of nutrients and pesticides. Regular cleaning of ditches can cause turbidity.
- Stopped tradition and/or forest plantation on the surrounding pasture increases the revegetation of the strand zone.
- Water take out under low water level periods can cause heavily lowered water levels and increased temperature, lack of oxygen and eutrophication problems.
- Drainage/re-filling of small waters, deepening, straightening and mudding of watercourses.

- For the typical *Chara* vegetation in these waters is the introduction of cyprinids (planktivorous fishes), especially carp (gräskarp), a real threat.
- Exploitation of the strand area.
- Boat traffic can cause turbidity.
- Forestry in the catchment area; drainage and protective drainage increases run off and therefore the risk for erosion and leakage of for example humic substances and particles. Buildings like Forest-roads/passages over till- or outflow can cause migration barriers.

Existence: Austria, Belgium, Denmark, Finland, France, Germany, Great Britain, Greece, Ireland, Italy, Netherlands, Portugal, Spain, and Sweden. (Airaksinen & Karttunen 1999)

5.1.4. Natural eutrophic lakes with Magnopotamion or Hydrocharition-type vegetation (3150)

Naturligt eutrofa sjöar med nate- eller dyblads-vegetation

These are lakes and ponds with mostly dirty grey to blue-green, more or less turbid, waters, particularly rich in dissolved bases (pH usually >7). The water is natural nutrient rich and well buffered. In this habitat-type there can be a wide spectrum of e.g. amount of phosphorous and nitrogen and Secchi depth. Typical are free-floating surface communities of the *Hydrocharition* or, in deep, open waters, associations of large pondweed (*Magnopotamion*). (SEPA 2001d; EC 1999)

Preconditions for a favourable status are for example a natural species composition without influence of non-native species, free migration possibilities in/to other water systems, natural water level fluctuations, and undisturbed hydrology. Many lakes of this type were during the selection influenced by anthropogenic lowered water level or regulation. In order to get or maintain conditions for a favourable conservation status shall the influence of possible earlier regulations be minimised. Positive for keeping the favourable conservation status is also that the natural or cultivated surroundings with wetlands, deciduous forest, and cultivated strand meadows exist further on. The distribution of this type at the coast and plains comes together with the most fertile agricultural used areas. This type and its surroundings have a species and individual rich flora and fauna and are the habitat for many red listed species (see table 6 for the typical species). This is a rather rare type compared to the other habitat types in Sweden. (SEPA 2001d)

Table 6. *Typical species for Natural eutrophic lakes with Magnopotamion or Hydrocharition-type vegetation in Sweden (Swedish Species Information Centre 2002); 2: red-listed species in Sweden (Swedish Species Information Centre 2002)*

Vegetation	
Hydrocharis morsus-ranae	(Frogbit/Dyblad/Froschbiss)
Stratiotes aloides	(Water-soldier/Vattenaloe/Krebsschere)
Lemna minor	(Common Duckweed/Liten andmat/Kleine Wasserlinse)
Spirodela polyrhiza	(Greater Duckweed/Stor andmat/Teichlinse)
Potamogeton natans	(Broad-leaved Pondweed/Gäddnate/Schwimmendes Laichkraut)
Ceratophyllum demersum	(Rigid Hornwort/Hornsärv/Rauhes Hornblatt)
Nuphar lutea	(Yellow water-lily/Gul näckros/Gelbe Teichrose)
Mammals	
Nyctalus noctula	(Noctule Bat/Stor fladdermus/Grosser Abendsegler)
Birds	
Podiceps cristatus	(Great Crested Grebe/Skäggdopping/Haubentaucher)
Tachybaptus ruficollis[2]	(Little Grebe/Smådopping/Zwergtaucher)
Podiceps grisegena	(Red-Necked Grebe/Gråhakedopping/Rothalstaucher)
Aythya ferina[2]	(Pochard/Brunand/Tafelente)

Anas querquedula[2]	(Garganey/Årta/Knäkente)
Anas clypeata[2]	(Shoveler/Skedand/Löffelente)
Larus ridibundus	(Black-Headed Gull/Skrattmås/Lachmöwe)
Circus aeruginosus	(Marsh Harrier/Brun kärrhök/Rohrweihe)
Botaurus stellaris	(Bittern/Rördrom/Rohrdrommel)
Chlidonias niger[2]	(Black Tern/Svarttärna/Trauerseeschwalbe)
Acrocephalus arundinaceus[2]	(Great Reed Warbler/Trastsångare/Drosselrohrsänger)
Anser anser	(Graylag Goose/Grågås/Graugans)
Amphibians	
Rana temporaria	(Common frog/Vanlig groda/Grasfrosch)
Rana arvalis	(………../Åkergroda/Moorfrosch)
Bufo bufo	(Common Toud/Vanlig padda/Erdkröte)
Natrix natrix[2]	(Grass Snake/Snok/Ringelnatter)
Rana esculenta	(………./Ätlig groda/Wasserfrösche)
Hyla arborea[2]	(Tree Frog/Lövgroda/Europäischer Laubfrosch)
Fishes	
Esox lucius	(Pike/Gädda/Hecht)
Perca fluviatilis	(Perch/Abborre/Barsch)
Rutilus rutilus	(Roach/Mört/Rotauge)
Abramis brama	(Bream/Braxen/Brachsen)
Beetles	
Bagous binodulus	
Bagous brevis	
Bagous czwalinai	
Donacia tomentosa	

Specific threats (SEPA 2001d):
- Leakage of nutrients from the surrounding agricultural areas increases the risk for 'polytrophication'.
- Intensive crop growing in the strand zone increases the risk for erosion and leakage of nutrients and pesticides. Regular cleansing of the ditches can cause increased turbidity in the water.
- Stopped tradition and/or forest plantation on the surrounding pasture increases the revegetation of the strand zone.
- Outtake of water under low water level periods can include highly lowered water levels, temperature increase and low oxygen.
- Exploitation of the strand area.
- Forestry in the catchment area; drainage and protective drainage increases run-off and therefore the risk for erosion and leakage of for example humic substances and particles. Buildings like Forest-roads/passages over in- or outflow can cause migration barriers.

Existence: Austria, Belgium, Denmark, Finland, France, Germany, Great Britain, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, and Sweden. (Airaksinen & Karttunen 1999)

5.1.5. Natural dystrophic lakes and ponds (3160)
Dystrofa sjöar och småvatten

These are natural lakes and ponds with brown tinted water due to peat and humic acids, generally are found on peat soils in bogs or in heaths with natural evolution toward bogs. The pH is often low, 3 to 6. In this habitat type there can be a wide spectrum of e.g. pH, watercolour and total phosphorous. The plant communities belong to the *Utricularietalia* order. The vegetation is sparse. The strand zone is often muddy and swimming moss populations can create quagmires. (SEPA 2001d; EC 1999; Airaksinen & Karttunen 1999)

Preconditions for a favourable status are for example natural surroundings with intact strand wetlands and strand forest, typical species composition without influence of alien species, free migration possibilities to other water systems, natural water level fluctuations and undisturbed hydrology. The typical species are shown in table 7. Brown forest lakes are the most common lake type in Sweden, they are found especially in the boreal region. This habitat type is less common in other parts of Europe. (SEPA 2001d)

Table 7. *Typical species for Natural dystrophic lakes and ponds in Sweden (Swedish Species Information Centre 2002); 1: Natura 2000 species (Habitats Directive, Annex 2), 2: red-listed species in Sweden (Swedish Species Information Centre 2002)*

Vegetation	
Utricularia minor	(Lesser Bladderwort/Dvärgbläddra/Kleiner Wasserschlauch)
Rhynchospora alba	(White Beak-sedge/Vitag/Weisse Schnabelbinse)
Carex lasiocarpa	(Slender Sledge/Trådstarr/Faden-Segge)
Carex rostrata	(Bottle Sedge/Flaskstarr/Schnabelsegge)
Mosses	
Drepanocladus s. lat. Spp	
Bird	
Gavia stellata[1,2]	(Red-throated Diver/Smålom/Sterntaucher)
Beetle	
Donacia aureocincta	

Specific threats (SEPA 2001d):
- Forestry in the surrounding area. Cutting of strand forest changes the hydrology and structure of the strand zone, causes turbidity, and increased addition of organic matter. Many of for dystrophic lakes characteristic species are depending on the strand forest as a biotope.
- Exploitation of the strand surrounding
- Liming of surrounding wetlands changes the conditions for the wetlands natural distributed species.
- Forestry in the catchment area; drainage and protective drainage increases run off and therefore the risk for erosion and leakage of for example humic substances and particles. Can cause turbidity and mudding of the bottom. Constructions like forest-roads/passages over in- or outflow can cause migration barriers.
- Agriculture in the catchment area; drainage and regular cleansing of ditches can cause turbidity. Intensive growing in the strand zones of the catchment area risks to cause leakage of nutrients and pesticides.
- Acidification – anthropogenic pollution of acidifying substances can contain a unnatural lowering of the lakes pH.

Wide distributed submersed moss populations (*Sphagnum sp*, *Chiloscyphus polyanthos*) are in general a sign for an ongoing acidifying process of the water system. (Airaksinen & Karttunen 1999)

Existence: Belgium, Denmark, Finland, France, Germany, Great Britain, Greece, Ireland, Italy, Netherlands, Portugal, Spain, and Sweden. (Airaksinen & Karttunen 1999)

5.2. Watercourse types

General threats are (SEPA 2001d):

- Regulation of the water flow by e.g. hydropower stations and dams; extension in today unregulated watercourse parts or increased regulation as for example lowered minimum water level in existing activities. Can cause interrupted flow dynamics, fragmentation/migration barriers, over-damming of wetlands- and strand surroundings, drying of watercourse parts and/or changed nutrient conditions.
- Forestry; Cutting of riparian closed forest causes increased solarisation/temperature, physical interruptions, lessened access to dead wood respectively fallout of organic matter and erosion. Drainage/Ditches cause increased off-flow and risk for erosion. Both interventions can cause turbidity and mudding of bottom and changed hydrology of the riparian environment. Forest roads/crossings can represent migration barriers.
- Agriculture; intensive crop growing on the riparian zone increases the risk for erosion, turbidity and leakage of nutrients and pesticides. Stopped traditionally *grazing*/hay-making and/or forest plantation on strand close pasture and meadows increases the revegetation rate of the riparian zone.
- Channelization, deepening and banking up to prevent flooding. Lessened water level variations and more even flow causes more even bottom and strand environments and lessens the conditions for species, which are depending on natural flow dynamics.
- Water take under low flow periods (especially tributaries in agricultural areas) contains risk for desiccation, increased water temperature and lack of oxygen.
- Introduction of non-native species (as e.g. Signal crayfish, *Elodea canadensis*) or fish populations (rainbow trout, pikeperch) can change the competition behaviour, spread infects and/or cause genetic contamination.
- Over-fishing.
- Exploitation. Building of houses and constructions in the water area can increase the need for flooding protection.
- Roads/Railroads; building, maintenance and traffic can cause turbidity and emissions of environmentally dangerous substances in ditches and watercourses. Bridges and conduits can cause migration barriers (risk for utter) and can be bottlenecks with high floods (with for example the risk for under-flushing of road banks).
- Discharge of pollutants from point sources, e.g. sewage, dumps, industry, pits, golf courses or other activity.
- Worsened water quality caused by anthropogenic diffuse sources – acidification, pollutants (inclusive metals) and eutrophication.

5.2.1. Fennoscandian natural rivers (3210)
Naturliga större vattendrag av fennoskandisk typ

This habitat type is characterised by boreal and hemi boreal natural and near-natural river systems or parts of such systems containing nutrient-poor water. The water level shows great amplitude, up to 6 m during the year. Especially during the spring the water is level high. The water dynamics can vary and contain waterfalls, rapid streams, calm water, and small lakes adjacent to the river. The water erosion causes a higher amount of nutrients towards the river–mouth, where sedimentation starts. In higher levels, the rivers are characterised by great, very cold water flows, coming from glaciers, deep snow beds and large snow-covered areas in mire- and woodlands. In addition, the water surface in placid river sections is frozen to ice every winter. These circumstances create ecosystems unique to this part of Europe (Fennoscandia). (EC 1999)

There can be a wide spectrum of e.g. pH, turbidity, phosphorous and nitrogen amounts in the water. Preconditions for a favourable conservation status are for example an unregulated water flow and natural flow dynamics, a high variation of the bottom substrate, vegetation, and riparian structures. No or insignificant influence by fragmentation, channelization, banking up, cleaning of the watercourse and repeated cleaning of sediment and vegetation should occur. The surrounding area should be in a natural condition with riparian forests, wetlands, or meadows. Riparian forests are important for shadowing and as a source for organic matter. The watercourse should be meandering on low-lying parts and on loam substrate, and the banks consist of bare soil due to eroding processes. The naturally existing riparian zone is here often small, but very important, and borders to agricultural used areas or meadows. Good water quality – relatively nutrient poor in most parts relatively nutrient poor, more nutrient rich in the downstream parts (SEPA 2001d). For typical species see table 8.

Table 8. *Typical species for Fennoscandian natural rivers in Sweden (Swedish Species Information Centre 2002); 1: Natura 2000 species (Habitats Directive, Annex 2), 2: red-listed species in Sweden (Swedish Species Information Centre 2002); 1: Natura 2000 species (Habitats Directive, Annex 2), 2: red-listed species in Sweden (Swedish Species Information Centre 2002)*

Vegetation	
Myricaria germanica	(…/Klådris/Deutsche Tamariske)
Salix daphnoides	(Violet-willow/Daggvide/Reif-Weide)
Taraxacum crocodes	
Cinna latifolia	(Sötgräs)
Sparganium glomeratum	(Gyttrad igelknopp)
Sagittaria natans x sagittifolia	(S. natans: Trubbpilblad, S. sagittifolia: Arrowhead/Pilblad/Gewöhnliches Pfeilkraut
Salix triandra	(AlmondWillow/Mandelpil/MandelblättrigeWeide)
Salix lapponum	(Downy Willow/Lappvide)
Hygrohypnum spp.[2]	
Mammals	
Lutra lutra[1]	(Otter/Utter/Fischotter)
Birds	
Gavia arctica[1]	(Black-throated Diver/Storlom/Prachttaucher)
Mergus merganser	(Goosander/Storskrake/Gänsesäger)
Mergus serrato	(Red-breasted Merganser/Småskrake/Mittelsäger)
Sterna hirundo[1]	(Common Tern/Fisktärna/Flußseeschwalbe)
Sterna paradise[1]	(Arctic Tern/Silvertärna/Küstenseeschwalbe)
Actitis hypoleucos	(Common Sandpiper/Drillsnäppa/Flußuferläufer)
Bucephala clangula	(Goldeneye/Knipa/Schellente)
Fishes	
Salmo salar[1,2]	(Salmon/Lax/Lachs)
Thymallus thymallus	(Grayling/Harr/Äsche)
Salmo trutta	(Brown Trout/Havsöring/Gemeine Forelle)
Lampetra fluviatilis[2]	(Lampern/Flodnejonöga/Flußneunauge)
Salvelinus umbla[2]	(Storröding)

Existence: Finland and Sweden (Airaksinen & Karttunen 1999)

5.2.2. Watercourses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation (3260)

Vattendrag med flytbladsvegetation eller akvatiska mossor

To this habitat type belong watercourses of plain to montane levels, with submerged or floating vegetation of the *Ranunculion fluitantis* and *Callitricho-Batrachion* (low water level during summer) or freshwater mosses. There can be a wide spectrum of e.g. pH, turbidity and nutrient amounts in the water. This habitat type exists in whole Sweden, as well as in small watercourses in agricultural areas as in forest streams. Good water quality – relatively nutrient poor in most parts, more nutrient rich in the downstream parts. Preconditions for a favourable conservation status are for example an unregulated water flow and natural flow dynamics, a high variation of the bottom substrate, vegetation and riparian structures. No or insignificant influence by fragmentation, channelization, banking up, repeated/regular cleaning of the watercourse, sediment and vegetation should occur. Free migration ways in connected water systems, natural surroundings with riparian forests, wetlands, or meadows are contributing a favourable conservation status. Riparian forest is important for shadowing and as a source for organic matter. The watercourse should be meandering on low-lying parts and on loam substrate, and the strands have bare soil due to erosion. The naturally existing riparian zone is here often small, but very important, and borders to agricultural used areas, meadows or forests (EC 1999; SEPA 2001d). For typical species see table 9.

Table 9. *Typical species for watercourses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation in Sweden (Swedish Species Information Centre 2002); 1: Natura 2000 species (Habitats Directive, Annex 2), 2: red-listed species in Sweden (Swedish Species Information Centre 2002)*

Vegetation	
Persicaria amphibia	(Amphibious Bistort/Vattenpilört/Wasser-Knöterich)
Potamogeton alpinum	(Red Pondweed/Rostnate/Alpen-Laichkraut)
Ranunculus trichophyllus	
Ranunculus peltatus	(Water crowfoot/Sköldmöja/Salz-Wasser-Hahnenfuss)
Myriophyllum verticillatum	(Whorled Watermilfoil/Kransslinga/Quirliges Tausendblatt)
Ranunculus fluitans[2]	(River-Water-crowfoot/Jättemöja/Flutender Wasserhahnenfuss)
Sparganium angustifolium	(Floating Burreed/Plattbladig igelknopp/Schmalblättriger Igelkolben)
Moss	
Fontinalis spp.	
Mammals	
Lutra lutra[1]	(Otter/Utter/Fischotter)
Castor fiber	(Beaver/Bäver/Biber)
Myotis nattereri	(Natterer´s Bat/Fransfladdermus/Fransenfledermaus)
Myotis dasycneme[1]	(Pond Bat/Dammfladdermus/Teichfledermaus)
Birds	
Alcedo atthis[1,2]	(Kingfisher/Kungsfiskare/Eisvogel)
Motacilla cinerea	(Grey Wagtail/Forsärla/Gebirgsstelze)
Cinclus cinclus	(Dipper/Strömstare/Wasseramsel)
Actitis hypoleucos	(Common Sandpiper/Drillsnäppa/Flußuferläufer)
Fishes	
Salmo trutta	(Brown Trout/Havsöring/Gemeine Forelle)
Silurus glanis	(Wels Catfish/Mal/Wels)
Noemachelius barbatulus[2]	(Stone Loach/Grönling/Bachschmerle)
Abramis ballerus	(Zope/Faren/Zope)
Aspius aspius[1,2]	(Asp/Asp/Rapfen)
Lampetra fluviatilis[2]	(Lampern/Flodnejonöga/Flußneunauge)
Petromyzon marinus[2]	(Sea Lamprey/Havsnejonöga/Meerneunauge)
Leuciscus cephalus[2]	(Chub/Färna/Döbel)
Gobio gobio[2]	(Gudgeon/Sandkrypare/Gründling)
Leucaspius delineatus[2]	(……../Groplöja/Moderlieschen)

Existence: Belgium, Denmark, Finland, France, Germany, Great Britain, Greece, Ireland, Italy, Netherlands, Portugal, Spain and Sweden. (Airaksinen & Karttunen 1999)

6. Parameters important for the (favourable) conservation status

For the choice of parameters, the tasks and formulations (in the Habitats Directive) describe:

1) The area the habitats cover and their natural range. It is not enough to monitor the covered area by taking samples, but it must also be known if the habitats natural range has changed.
2) The specific structures and functions shall be found in right quantities in the habitat. The expression 'specific' indicates that not all relevant structures and functions have to be monitored in the Natura 2000 system, but the most important ones for the habitat type.

- Structures/processes are specific structures or processes that are of deciding meaning for the conservation status of a habitat. For example flooding, tide-water-influence, groundwater level, etc. (SEPA unpublished)
- Functions are specific functions that a habitat can have for an organism group, for example resting place for migrating birds or breeding places for birds. (SEPA unpublished)

3) Typical species of a habitat. The term 'typical species' could be defined as:

- species that are mentioned in the habitat description (Interpretation Manual, EC 1999), and/or
- species that exist generally in one or more subtypes of the habitat and at the same time indicate an aspect of the habitat that is interesting to monitor, and/or
- species that are national or international red-listed, or listed in conventions or in EU-directives (Birds Directive and Habitats Directive (Annex 2 and 4)), or have an important part of its occurrence in this habitat type. If typical species disappear from the habitat, an important part of the conservation value of the habitat we want to protect disappears too. (SEPA 2001a)

(4) External pressures are also important to monitor in general (e.g. clear cutting on shores, ditching)

Important parameters for the monitoring of Natura 2000 freshwater habitats will be presented here and partly discussed, especially when they differ considerably for different habitats. Though, many parameters are the same for all lake respectively watercourse types. To begin with, several possible monitoring parameters are named. Later, they will be divided into basic level and supplementary level, since it will not be possible and necessary to monitor every parameter. Further, not every parameter will have the same importance for every habitat type. Since the parameters will just shortly be presented here and only their most important aspects in this context highlighted, it is pointed out to special literature for more details. Choosing important parameters for the different habitat types, specific characteristics and threats (as named in the habitat descriptions) will be concerned, as well as the habitat needs of the different species. The species are just a choice, they are not complete, and the concentration will be on the typical species of each habitat type, which are listed in the habitat descriptions.

Specifics of habitat types are for example that the oligotrophic lakes are often situated on sandy soils, which are known to have the potential of leaking nutrients and pesticides etc to the system. These lakes are also strongly threatened by acidification, whereas the water of the hard oligo-mesotrophic and the eutrophic lakes is well buffered.

Indicator species are important for getting to know changes that happen in the long run in a habitat. Parameters as water quality show the moment situation, but by measuring them only occasionally, important changes can be missed, especially in watercourses. Indicator species can sometimes show better a change than the typical species, even though most of the time the typical species have a very small range of preferred habitat conditions (what makes them typical for and indicating a certain kind of habitat). Bio-indicators show for example stress, disturbances, air pollution, eutrophication, acidification, and hydrological influences. Asking a specialist for a specific taxonomic group about its indicator values, everyone will feel its group to be important. Without claiming completeness, some indicators and their characteristics are listed here and it will be looked on how well they are suitable for monitoring the conservation status of a habitat.

6.1. Parameters for Natura 2000 freshwater habitats

Water quality (lakes and watercourses)
The water quality is used for the description of the situation (basic data) and changes in consideration to the chemical and physical conditions and living conditions for biota. The results can tell about the impact of air pollution, different types of discharge, as well as land-use and other interference or measures in the catchment. They can be important for detecting signs for e.g. acidification and eutrophication. Basic parameters are temperature, conductivity, pH, Ca, Mg, Na, K, alkalinity, SO4, Cl, NH4-N, NO2+NO3-N, TOT-N, PO4-P, TOT-P, TOC, absorbency (watercolour), oxygen, chlorophyll a, Secchi depth, and Si. The water quality should be measured in all lakes. Monitoring of the nutrient supply in the tributaries can be necessary on a supplementary level. Supplementary parameters can further be Fe, Mn, Al (Cu, Zn, Cd, Pb, Hg, Cr, Ni). Analyses of heavy metals are expensive and are mainly recommended for waters directly influenced by metal contamination or acidification. There will be a problem with substances that are not very well known today, as for example pesticides. (SEPA 1996c,d)

Phytoplankton (lakes)
Algal species composition is an appropriate early warning indicator (Wiederholm 1992). The phytoplankton community changes with different environmental conditions and the analysis of it can therefore give good information about the water quality and its changes of the last time, e.g. showing signs of eutrophication and acidification, in lakes. This parameter is important in areas connected to agricultural used areas and in easily acidified areas. Compared to macrophytes, phytoplankton is directly depending on the water and give therefore a good picture of the water quality. (SEPA 2000b)

Periphyton (diatoms) (watercourses)
Periphyton have a similar role for watercourses (Wiederholm 1992) as phytoplankton for lakes has. Compared to macrophytes they are directly depending on the water and give therefore a good picture of the water quality. The periphyton community changes with different environmental conditions and the analysis of it can therefore give information about the water quality and its changes of the last time, e.g. showing signs of eutrophication and acidification. This parameter is very important in areas connected to agricultural used areas and in easily acidified areas (SEPA 2000c).

Zooplankton
The zooplankton community changes with several environmental changes, as eutrophication, acidification, contamination by metals, and changes of the fish community. Since the zooplankton community is regulated both by the phytoplankton production and by predation of fish, the species composition and biomass is influenced by several factors. It is not always clear why specific changes occur. Since little is known and studied about the factors influencing the zooplankton community (Wiederholm 1992), benthic fauna and phytoplankton are more useful in monitoring. Monitoring of the zooplankton community can

be suitable for example when changes in phytoplankton or fish community shall be studied. (SEPA 1996a)

Macrophytes

Studying changes in the distribution of macrophytes, they can give for example knowledge about eutrophication, acidification, or physical disturbance. In general, disappearance of first isoetids and then elodeids and growth of non-rooted floating leaved macrophytes (lemnaceae) indicates eutrophication. Acidification is in general indicated by expansion of *Sphagnum* mosses and sometimes *Nymphea alba* to deeper water. Rare species may indicate high conservation values (H. Sandsten, personal communication, 20.06.2002). Macrophytes are good trophic indicators between 8-45 µg/l. At higher values it gets very vague (J. Schoenfelder, 15.08.2002 personal communication). For examples of the indicator value of vascular freshwater plants, see Appendix 1.

Mosses

Indicating acidification processes (as *Sphagnum*).

Vegetation zones/types and mosses (lakes)

The freshwater vegetation is most often the strongest group in the habitat descriptions and varies between the different habitat types, whereof it will be discussed for the single types.

For the oligotrophic lakes, submerged vegetation, as isoetids and elodeids, and mosses are characteristic. For the oligo-mesotrophic lakes are additionally amphibious short annual pioneers/ephemerophytes and emergent macrophytes (helophytes) important. Their occurrence or disappearance indicates changes, as e.g. *Sphagnum* indicates an acidification process. That is important for lakes in easily acidified areas. The submerged vegetation depends on clear water (as e.g. small amounts of plankton and humic substances) that the light can reach through the water column. Certain macrophyte species (as e.g. lemnids, *Ceratophyllum demersum*, *Potamogeton pectinatus*) (SEPA 2000a) indicate high nutrient amounts in the water and their occurrence and number should be observed. For the typical annual macrophyte species of the oligo-mesotrophic lakes, exposed/bare strands are important (depending on water regulation, land-use of the strand – grazing).

For the hard oligo-mesotrophic lakes, submersed isoetids and charophytes are characteristic. The distribution and population changes of the vegetation, the charophyte algae carpets, as well as the mosses (for acidification) can be used as indicators for changes. *Chara* species are very sensible to eutrophication and shadowing by phytoplankton and epiphytes. The occurrence of charophytes (of which many species are red-listed) is seen to be a very important aspect to be integrated in a monitoring plan, and especially the recognition of different species. Different species have totally different environmental demands and therefore also different meaning for other organisms (Blindow, 2002, personal communication).

Nutrient demanding lemnids, elodeids and floating-leaved vegetation as well as mosses are characteristic for the eutrophic lakes. For the dystrophic lakes, elodeids, floating-leaved vegetation, helophytes, and mosses are characteristic. Their occurrence or disappearance indicates changes. Further, a natural succession of closing the open water column by the vegetation can occur, which can be intensified by a lowered water level. For all other lake types, overgrowing of the open water surface can be a sign for rising nutrient amounts in the water.

Vegetation zones/types (watercourses)
As well the vegetation composition as its distribution can be a good sign for changes, for example the occurrence/non-occurrence of freshwater mosses, and spreading and species composition of floating-leaved vegetation. Overgrowing of the whole water column will be a sign for rising nutrient loads. Exposed bare shores are important for some typical macrophyte species.

Land-use close to the shore and on a larger scale (lakes and watercourses)
This parameter is especially important for all lakes that are not surrounded by other protected (and monitored) areas and/or have intensive agriculture or forestry (clear-cutting) or drainage/ditching in the surrounding. Agriculture in the surrounding of especially the nutrient poor lakes has a special importance due to the sandy soils, nutrients and pesticides can easily leak out. When possible, the land-use in the catchment area should be considered too.

Buffer zones on forest and agricultural land/Riparian forest (shadowing) (lakes and watercourses)
Buffer zones bordering to land used for agriculture and forestry have a very strong importance, preventing the lakes from high nutrient loads, erosion, etc. These threats have to be seen very strong, especially for the oligotrophic lakes, because they are characteristically situated on sandy soils, which are known to leak nutrients, pesticides etc. very easily. Buffer zones in the catchment are also important, but probably not realistic to be monitored for large catchment areas.

Influences on the near surroundings (lakes and watercourses)
This can be for example swimming places/beaches, which can be a threat to the vegetation, summer cottages and other buildings, boat places, intensive fishing activities, fish farming, roads, urban areas, industries, recipient for factories and municipalities, golf courses, dumps, shooting-sites, clear cutting, storm water, free time/tourist activities (highly frequented hiking paths), etc. The influence on the tributaries is also important to be considered.

Water level (lakes)
The water level is important for the vegetation of the lakes, especially when there is typical annual vegetation, which depends on water level fluctuations, as in the Natura 2000 oligo-mesotrophic lakes. But unnatural water regulations can have other effects too. For example intensifies a lowered water table the succession of overgrowing, especially in eutrophic and dystrophic lakes.

Water level/-flow (watercourses)
Natural water level fluctuations are important for many species in a watercourse. However, most watercourses are regulated by for example dams (partly not in use anymore) and hydropower stations. During the management work changes have to be carried out at some places to save not only typical species (vegetation) but also the habitats itself. Changing the admissions given to the power stations can be difficult, since the existing ones can be very long lasting. The phenomenon 'Nolltappning' (no-water-flow at all during some periods possible) should be eliminated at least in the concerned areas.

Migration ways (lakes)
Migration barriers occur up- and downstream for almost all lakes. They stop the natural exchange of species, between others of Natura 2000 species as otter and several fish species.

Migration ways/Fragmentation grade (watercourses, main flow and tributaries)
As there are (badly placed) conduits, dams (sometimes not in use anymore), hydropower stations, and bridges. The fragmentation grade is not only for the main flow, but also in the tributaries important. In watercourses where only parts are protected by Natura 2000 should the measures include important watercourse parts even if they are not included in the Natura 2000 site.

Liming effects (lakes and watercourses)
The liming of wetlands and lakes upstream can have effects on the species in a lake. Monitoring of fishes, invertebrates and the water quality can show, how strong these effects are; this monitoring is done due to special programs.

Introduction of non-native species (and their effects) (lakes and watercourses)
As there are relevant for example *Pacifastacus leniusculus* (Signal crayfish) (especially when the native crayfish - *Astacus astacus* - occurs), *Elodea canadensis*, implanted salmon, rainbow trout.

Bottom substrate (lakes and watercourses)
The bottom substrate is very important for all kinds of species.

Epiphytes (lakes)
Epiphytes can be a danger to charophytes

Species composition (relationship phytoplankton/submersed plants) (lakes)
This parameter can give information on the nutrient state of the water, especially for the eutrophic lakes.

Channelization, banking up, and repeated cleaning of the sediment and vegetation (watercourses)
These parameters have a strong influence, also when they only appear in the catchment.

Water take out during low flow periods (irrigation) (watercourses)
Water is taken for purposes of agriculture, but also for fish farming, and golf courses. This is regulated be a water regulation plan ('Vattenhushallningsplan'). It should be avoided during low-flow periods.

Roads/Railroads/Bridges/Conduits (watercourses)
These elements do not change very often, but they can be a problem as e.g. migration barriers. They can be a danger for otter, since these animals do not like to swim under bridges or similar 'roofs'. Because of this, they walk over the streets and are threatened by traffic accidents (Föreningen Rädda Uttern i Småland 1995).

Fishes
Some fish species are valuable early warning indicators (Wiederholm 1992). Typical fish species are listed for almost all lake types.

Metals in fish and in freshwater mosses
Freshwater mosses appear mainly on exposed bottoms as well in lakes as in watercourses. The metals in freshwater mosses and their periphyton can be measured, to get a preliminary

picture of (long-term) metal pollutionand its effects in a water recipient. Especially in watercourses it can be difficult to measure the metals in water samples, since the samples do not cover the constant flow. Instead, a stationary medium is investigated that has been accumulating the metals to amounts that are 1000-10000 times higher than in the water (SEPA 1986).

Cyanobacteria/*Nostoc zetterstedtii*
This more or less spherical colonies building cyanobacteria is found in some Natura 2000 lakes in the County of Jönköping. It is very sensible and appears only in clear, nutrient-poor, biodiversity-rich and relatively large lakes, 60 lakes known in Sweden, one in Finland and one in the Pyrenees (Bengtsson 1996). It needs sand- and gravel-bottoms or grows on *Isoetes*-mats, due to the threat of being over slammed by sedimented material. *N. zetterstedtii* is threatened by lowered water level, since the mentioned bottoms disappear by this. Other threats are discharge of polluted water and acidification/liming. Since these cyanobacteria depend very strongly on clear water, its disappearance is a good indicator for mudding, humic substances etc. Further its occurrence shows if a lake had not had an unstable pH, humic water or any plankton algae blooming over a longer period of time. (Bengtsson 1996)

Benthic (littoral and profundal) fauna
By monitoring the benthic fauna species of different biotopes, the situation of the water (natural value, biodiversity, acidification status, pollution status) is investigated with. Different species are sensitive for different chemical and physical factors. In difference to the water quality gives the benthic fauna an integrated measure of the situation from past to today. The benthic fauna is not only a good indicator for different changes, it is also important as food for birds and fishes. By sampling profundal fauna, it can happen, that one takes the sample from a oxygen-free zone and therefore get wrong results. Therefore, if a choice has to be done between littoral- and profundal fauna, the littoral fauna will be taken. Insect larvae are good indicators, but are very sensible to climatic conditions, wherefore one has to know the taxa regionally very well and know their ecology. For this will in most cases not enough data be available. (SEPA 1996e, f, g)

Freshwater pearl mussel
The Freshwater pearl mussel exists in many of the habitats and is is a very good indicator for acidification and any kind of water pollution. It is also Natura 2000 species, therefore it should be recommended to observe its population in these sites too.

Crayfish
The native crayfish species is rare and red-listed. Crayfishes are in general very good indicators especially for acidification and have been monitored in the County of Jönköping since a long time.

Fishes
Fishes give a good picture of the freshwater environment. Since they are long living and rather easy to identify they can be good indicators for environmental changes in a long run. Changes of the fish community give information about effects on disturbances since different species are different sensitive for chemical, hydrological, and climatic changes. This parameter is of course only suitable when no fishes have been introduced by men (J. Schoenfelder, 15.08.2002 personal communication), as it is done for example in the nature reserve Hökensås.

Birds

All habitat types have typical bird species and often Natura 2000 bird species. Due to H. Sandsten (personal communication 19.06.2002) only a few bird species are very good indicator species, but many are connected to a specific habitat during the breeding season (for example Marsh harrier needs large enough reed-parts to breed in). The stream living (rapid water) species (Grey wagtail, Dipper and kingfisher) are connected to running water with decent access to insects and fish. But they are often influenced by the need of suitable living places as sandbanks respectively old stone bridges or similar. Loons are a good sign for an oligotrophic lake with a good population of small fishes. Birds can therefore give a decent indication for some basic characteristics of a freshwater system. However, to decide the status of a lake it will be best to look on the density of the birds. The density of both herbivores and on invertebrates feeding birds has been shown to change together with turbidity and the amount of vegetation. Even if birds can be very typical, they are not the best indicators for a certain kind of habitat type. The monitoring of birds will be mostly not due to their indicator function but because of other reasons.

6.2. Parameters being monitored due to the Water Framework Directive

Even if the work on the monitoring due to the Water Framework Directive is still going on and most of the details are not decided yet, the main monitoring parameters are known. The quality elements for the classification of the ecological status for surface waters can be found in Annex V. For lakes and watercourses there are a number of biological elements, as composition and abundance of freshwater flora, benthic invertebrate fauna and fish fauna (+ age structure) and for lakes additionally phytoplankton (+ biomass). For supporting the biological elements, there are further hydromorphological, chemical and physiological elements (see table 10). This classification shows that the main importance will be on the biological parameters. All prioritised substances (Annex IXa) that are discharged to the water, as well as other substances that are discharged in considerable amounts, shall be monitored.

Table 10. *Quality elementssupporting the biological elements for the classification of the ecological status for surface waters (WFD Annex V)*

Hydromorphological elements supporting the biological elements
Hydrological regime
Quantity and dynamics of water flow
Residence time (for lakes)
Connection to ground water bodies
River continuity
Morphological conditions
Lake/River depth and width variations
Quantity, structure and substrate of the lake bed
Structure and substrate of the river bed
Structure of the lake shore/riparian zone
Chemical and physiological elements supporting the biological elements
General
Transparency (for lakes)
Thermal conditions
Oxygenation conditions
Salinity
Acidification status
Nutrient conditions
Specific Pollutants
Pollution by all priority substances identified as being discharged into the body of water

Pollution by other substances identified as being discharged in significant quantities into the body of water

6.3. Parameter overview (table)

The following table gives a summary of the presented parameters and their importance for different habitat types.

Table 11. *Suggested parameters (X: basic level; x: supplementary level)*

Parameter (structures and functions)	***Oligotrophic lakes***	***Oligo-mesotrophic lakes***	***Hard oligo-mesotrophic lakes***	***Eutrophic lakes***	***Dystrophic lakes***		***Fennoscandian watercourses***	***Watercourses***
Water quality	X	X	X	X	X		X	X
Water quality/metals	x	x	x	x	x		x	x
Phytoplankton	X	X	X	X	X		---	---
Periphyton							x	x
Submersed vegetation (including mosses and algae)	X	X	X	x[2]	x			
Emergent and floating leaved vegetation (including mosses)	x[2]	X		X	X			
Vegetation in watercourses							X	X
Exposed/bare lake shores (distribution);		X						X
Revegetation grade				X	X			
Land-use (close to the lake shore and also in a larger scale)	X	X	X	X	X		X	X
Buffer zones on forest/agricultural land	X	X	X	X	X		X	X
Influence on the near surroundings	X	X	X	X	X		X	X
Water level/flow[1]	x	X	x	x	x		X	X
Migration barriers/Fragmentation grade (main flow and tributaries)	x	x	x	x	x		X	X
Liming effects (when liming occurs upstream)	(x)	(x)	(x)	(x)	(x)		(x)	(x)
Introduction of non-native species (fishes)	X	X	X	X	X		X	X
Bottom substrate	X	X	X	X	X		X	X
Epiphytes			x					
Species composition (phytoplankton and submersed macrophytes)				x				
Zooplankton	x	x	x	x	x			
Nostoc	x	x						
Channelization/banking up							x	x
Cleaning of sediment and vegetation							x	x
Water take out	x	x	x	x	x		X	X
Roads, Railroads, Bridges, Conduits								
Fishes	X	X	X	X	x		X	X
Sediment chemistry	x	x	x	x	x			
Metals in fish	x	x	x	x	x		x	x
Metals in freshwater mosses	x	x	x	x	x		x	x
Littoral fauna in lakes/Benthic fauna in watercourses	x	x	x	x	x		x	x
Profundalfauna[3]					x			
Crayfish	x	x	x	x	x		x	x

Freshwater pearl mussel (Natura 2000 species)							x	x
Monitoring of measures (e.g. land use of the strand as pasture, meadow)	x	x	x	x	x		x	x
Additional (typical) species								
Otter (Natura 2000 species)							√	√
Beaver (Natura 2000 species)[4]								√
Birds	√	√		√	√		√	√
Fishes		√		√			√	√
Bats				√				√
Amphibians				√				
Insects				√	√		√	

1 the parameter 'water level' will be discussed
2 not listed typical species, but could be important anyway
3 when littoral fauna not possible to be monitored (for example quagmire)
4 a typical species, but does not occur in the County of Jönköping

7. Methods for monitoring the relevant parameters

For the purpose of monitoring the different elements of Natura 2000 sites, adequate and first of all 'accepted' methods should be used. Regarding this, the standard methods from the Environmental Monitoring Handbook ('Handbok för miljöövervakning', SEPA 2002i) will have first priority. However, when elements are not covered by this, other methods will have to be used. These ones shall have been applied in several counties or other countries; quality aspects and comparability with other methods are important to consider too (SEPA 2001a). The methods should be able to be used in as many habitat types as possible or for so many species as possible (SEPA 2002b) and they should be used in a way that is useful for evaluating if the favourable conservation status exists or not.

The best available and suitable methods will be shortly presented and evaluated under the aspect of their use for the monitoring of Natura 2000 habitats (including the economically aspects), since this has not done before. Therefore, the focus is on possible monitoring levels, frequencies, costs and covered parameters. A summarising table can be found in the end of this chapter. For the detailed method descriptions, it is referred to the special literature.

7.1. Standard methods from the Environmental Monitoring Handbook

The environmental monitoring handbook ('Handbok för Miljöövervakning', SEPA 2002i) contains recommendations for planning and manuals for carrying out monitoring projects (in form of assessment types). Its overall aim is to get a better comparability between the collected data in whole Sweden.

'Site description'
This investigation type is meant for defining a minimum level for the information collected in the field during biological surveys (as investigations of benthic fauna and diatoms, and especially for watercourses also fish and freshwater pearl mussel) in the littoral zone of watercourses and lakes (obligatory). It should always be used in connection with other investigation types. This method contains a protocol, which gives a general description of the site, in form of two levels, basic information and additional (obligatory) information. Included

parameters are for example the geographical position, area, physical structure, substrate, vegetation, closer environment, and several forms of impacts. Parameters that are used both in this method and in 'habitat survey', have the same classifications. Since this method is more a part of other investigation types than one on its own, the costs will only be for the time for filling in the protocol (30-60 minutes). It will be enough to do the site description every third to fifth year. (For the method description, see SEPA 2001b)

Water quality of lakes
For the basic level of Natura 2000 purposes, the extensive frequency (as suggested in the handbook once per year or even less) will be adequate. This will only be able to give information on trends, but it will not be very specific, as variations during a year are not known. On the supplementary level, intensive frequencies (as suggested 4-8 times per year) will give information on the situation and processes in a lake. Possible are depth profiles (intensive, for the supplementary level of Natura 2000), or only surface water sampling (extensive, for the basic level of Natura 2000) (in stratified situations even one bottom sample will be necessary). The sampling will be done on a representative point of the lake, mostly over the deepest place, but can be done in relevant cases also at the outflow. For dystrophic ponds and lakes that are surrounded by mires (and partly covered by quagmires), sampling from a helicopter will be necessary. Laboratories will do the analyses due to European and/or Swedish standards. (For the method description, see SEPA 1996c)

Water quality of watercourses
This method includes three different program types:
a) for characterising the flow in the catchment and outgoing from the catchment area,
b) for analysing the substances to get to know the levels compared with reference values (which have to be given or specified in the first years) (compliance monitoring), and
c) to give background information for biological investigations in the watercourse.

The second possibility will be the one for the Natura 2000 purposes on a basic level. Recommended is that the sampling is done at least six times per year, the best would be every month. This can be done on the supplementary level. For the analysis, only one sampling is done in the middle of the watercourse, 0,5 m under the water surface. The analysis itself will be done in laboratories due to European and/or Swedish standards. The single chemical parameters can vary slightly between different existing programs. (For the method description, see SEPA 1996d)

Phytoplankton in lakes
There are four different possibilities:
1) taxa/species analysis (indicator species),
2) analysis of the number and biovolume of the different taxa/species (quantitative values to compare in space and time),
3) analysis of the biovolume of different species groups (indicator value), and
4) analysis of the total biovolume of planctic algae (in relation to the amount of chlorophyll a and the concentration of phosphor)

The sampling should be best done several times (1-7) during the vegetation period, to follow the changes and development of all different species. The composition and changes during the seasons give good information about the water quality. By sampling only once a year, how it will be suggested for the basic level, a classification of the water quality can be done, but it takes many years until changes can be detected through average values and deviations. (For the method description, see SEPA 2000b). In Lake Vättern, a LIFE-project will test the possibilities of monitoring between others the phytoplankton/chlorophyll a concentration with help of satellite pictures.

Zooplankton in lakes
Qualitative sampling is done when the investigation aim is to identify and analyse occurring species. For comparisons of the zooplankton community between different lakes or for time series, quantitative sampling is done (relative and/or absolute number of species). The sampling frequency can vary from one sample in two weeks to one time/year. (For the method description, see SEPA 1996a)

Benthic fauna in the littoral of lakes and in watercourses
There are two different levels described in the handbook:
<u>Investigation:</u> the level for getting a good picture of occurring species (indicator), since the sampling will be done at several (30 samplings within a 50 m long part) different biotopes. The results will tell about the natural value/the biodiversity in a water body. The present species indicate the acidification and pollution situation of a lake. For the purpose of the acidification situation, the sampling shall be done directly after the spring-flood, for the pollution status in late summer, and for the best picture of the biodiversity in early summer or late autumn. The recommended frequency is between once per month and every fifth year.
<u>Time series:</u> for investigating changes and comparing different sites. To get comparable and representative values, the sampling is always done on a well-defined bottom substrate (fix point) and at different times of the year, since the benthic fauna shows large variations in time. The sampling should be done (in spring and) autumn to avoid the strong variations during the summer. The recommended frequency is between two times per year and every fifth year. (For the method description, see SEPA 1996e/f)

Benthic fauna in the profundal and sublittoral of lakes
This method is similar to the one for benthic fauna in the littoral; the main difference is that both a boat and a collector are needed for the sampling. That makes the sampling more expensive (material and working time). One problem with sampling benthic fauna can be that the sample is taken on an oxygen-free place of the lake bottom and therefore will give wrong results. The sampling place for the littoral fauna can be better chosen. A recommended frequency is two times/year to once every fifth year. (For the method description, see SEPA 1996g)

Freshwater mussels
The mussel inventory includes all freshwater mussels, between others the Freshwater pearl mussel (Natura 2000 species). The inventory is done with a water scope and should be carried out every third to fifth year. The recommendation is to investigate 15 places per watercourse-stretch. (For the method description, see SEPA 1999)

Standardised gillnet fishing (lakes)
(Swedish standardised method for sampling freshwater fish with Nordic multi-mesh gillnets)
The method will give information on age, numbers, and species of the fish community; gillnets with different mesh sizes are used. There are two investigation types:
- Standardised fish sampling: for time series or for doing quantitative comparisons of fish occurrence between lakes (use of assessment instrument). The intervals of sampling should not be longer than more than three years (best one). The number of nets depends on the size and the depth of a lake (8-64 nets)

- Investigative fishing: simplified, for a picture of the fish species and amount in a lake; less nets are needed (4-24).
Problems are for example that species living at the bottom will most likely be underestimated, and the method is not useful for very large or very small lakes. (For the method description, see SEPA 2001c)

Electro fishing in watercourses
Electro fishing can be done for monitoring a key-species (qualitative) or to get a whole picture of the existing fish community (quantitative). (For the method description, see SEPA 2002f)

Metals and organically pollutants in fish
As an indicator for threats to the biodiversity. Possible for one sampling to get to know the moment situation and for time series to get to know possible long-term changes. (For the method description, see SEPA 1997b)

Macrophytes in watercourses
This method is divided into three levels:
- point observations (short parts of the watercourse, as specific vegetation types or key-biotopes),
- evaluation investigations (longer parts, to find the most representative place or to evaluate a watercourse), and
- full investigation of the whole watercourse.

For the Natura 2000 purposes, the first ambition level of this method will be suitable. However, in the beginning of the monitoring program, one inventory on the second (longer stretches) level could be meaningful, to get the information necessary for the choice of transects/reference places (permanently marked) (this information can also be collected during the habitat survey, see there). Since the changes between years can be large, the handbook suggests yearly investigations in the beginning (in late summer) and later a lesser frequency (every third to fifth year). The method includes further information on the bottom-substrate (protocol), watercourse width, water level, flow-speed, and watercourse-profile. Plant species can give a good picture of the present situation, using their indicator value. The problem is that there exist no 'Environmental Quality Criteria' for macrophytes in watercourses yet, since species composition and distribution of both dominating and rare macrophytes in watercourses are relatively badly known.

When the place has been chosen, the macrophyte inventory will take half a day (one day for the first time) for two people (average/place (transect)). When a watercourse has very heterogeneous vegetation or the site is large and the inventory very accurate, or that there are several different threats to the vegetation, it will be recommended to monitor several places of one site (suggestion: 100 m^2 per site or five transects). The costs rise with half a day/inventory place. (For the method description, see SEPA 2002d)

Macrophytes (submersed) in lakes
This method, which includes also macro algae (as charophytes) and freshwater mosses, is also divided into three levels:
- monitoring of a specific vegetation type (e.g. specially threatened),
- investigation of a part of the lake (mainly when only a part is vegetated) and
- total investigation of the whole lake

The last two ones will be used when the interest is to see changes of the submersed vegetation due to specific environmental changes. Reference places will have to be chosen and permanently marked by GPS, photo, etc.
There are three observation techniques:
1. Underwater photographing and sampling by divers (especially important for deep lakes)
2. Free-diving and/or SCUBA diving (along transects with help from divers/swimmers) (especially important for deep lakes)
3. Observations from a boat (not so deep lakes or part of lakes; water scope, rake, and idealistic circumstances are needed: flat bottom, little wind, well done buoy marking).

Since diving is expensive, this method will not be used in the following analysis, even if it would be the best and most accurate method for many lakes.

Submersed plants are investigated every 0,25 or 0,5 m. For statistics the estimation of density of at least 10 squares in each depth-interval is necessary. Time-series should be done yearly, since the changes can be strong. A sparse monitoring could hide changes and prolong the time, until these can be seen. With stabile conditions, the investigations can be done only every third to fifth year and be more frequently again when changes occur. The costs will be much higher in the beginning when the place(s) for the monitoring will have to be chosen (the Habitat Survey will give a very good ground for this) and established, since for this an overview inventory of the lake has to be done. When the place has been chosen, the macrophyte inventory will take half a day for 2 people (average/place). When a lake is very heterogeneous concerning the vegetation or the lake is large and the inventory very accurate, or that there are several different threats to the vegetation, will be recommended to monitor several places of one lake. Then, different vegetation communities have to be chosen for the specific purpose. The costs rise with half a day/inventory place. (For the method description, see SEPA 2002c)

Charophytes have a meaning as indicators; they are very typical for clear, nutrient poor water. Because of their indicator function but also because many of them are threatened, they should be determined to species level. The determination is not very easy and requires a specialist. The work on a determination key is ongoing (I. Blindow, personal communication).

Macrophytes (emergent and floating-leaved) in lakes
This method is still under development and not published yet. It contains two ambition levels:
1. monitoring of a whole lake with help of aerial photographs (free time interval)
2. development of specific vegetation parts by direct field investigations of the species and the biomass

For the choice of film see part about aerial photographs. The pictures should be taken from right above the lake/watercourse and be done in late summer, when all vegetation is developed. The frequency is given as every 10 years as long as field controls do not show that there are some changes and more frequent monitoring is necessary. Depending on the size of the vegetation belt, a part of the lake or the whole lake has to be photographed. For analysing broad vegetation belts, 1:30 000 is enough, smaller/more varied belts need larger scaled pictures. With help of straw density and weight estimations in the field, biomass and its changes is documented. A description of the nearest surrounding is included. (SEPA 2001, method description not published yet)

Standardised crayfishing (with traps)

Possible are quantitative investigations and investigations to see if crayfish exists at all. The number of traps per place depends on the lake/watercourse size and is described in the method description (see SEPA 1996b).

Periphyton in running water – diatom analysis
This investigation type includes species composition, species number, and relative occurrence of species, especially indicator species, and can be done for

- investigating the water quality in a watercourse (also in a larger area)
- identifying places that are suitable for more detailed and long-running investigations or measures
- localise point discharge
- knowledge for comparison of sites in time and space

For time series of water quality can once per year be enough. The method can be co-ordinated with other investigations in running water, as for example water quality, benthic fauna, electro fishing. This method (parameter) is not used very much today, also due to the reason that not many specialists can do the species analysis. (For the method description, see SEPA 2000c)

7.2. Other relevant methods/Parameters without standard methods

Habitat survey ('Biotopkartering')
Riparian zone of watercourses
The aim of this method is to localise and quantify different biotopes in watercourses and their nearer surroundings, as well as to describe their grade of influence. The results shall be used for example for natural value assessments as well as for assessments of influence and the need for measures. The method builds on an aerial photograph analysis for a first characterisation of the different parts of a site and thereafter a walk along the watercourse where information (parameters see table 12) in four different protocols and on maps is collected. The watercourse and its banks (nearer surroundings) is dealt up in separate part stretches, and even all migration barriers and inflowing ditches/tributaries are described. (for method description see Jönköping County Administrative Board 2000a)

This method could be very well used for the monitoring of Natura 2000 sites, since it includes many of the aspects that are necessary for determining if a favourable conservation status exists. Since this method is based on walking along the watercourse, it does not include parameters of the open water body, as e.g. water quality, phytoplankton, and fishes (but their habitat requirements). The method is going to be in the handbook for environmental monitoring in the future (S. Vävare, handout during a seminar 03.10.2002).

Table 12. *Included aspects in 'habitat survey'*

Freshwater biotopes: Local information (length, width, depth, etc.), bottom substrate, vegetation (coverage, groups, species), stream conditions, shadowing, dead tree, flow/extend (straight/meandering), cleaning and other influence, salmon/trout biotope (spawning, growth, standing places), structure elements (lake outflow, ox-bow lake, delta, stone setting, etc.). Surrounding/immediate surrounding: (Larger and immediate) surrounding land-use, buffer zone (width, land-use), bush layer (width), shadowing. Tributaries/ditches: Length, width, depth, influenced of land-use, erosion risk, buffer zone. Migration barriers: Local, information (type, fall height, Q, natural), fish information (grade of difficulty for trout/salmon respectively other fishes, damage/loss), usage (today, previous, cultural interests, owner), measures, fish ways (type, function), sketches. Bridge protocol

Lake shores
For lakeshores the 'habitat survey' has the same structure and differs only in details from the method used for watercourses. It is also divided into two levels, detailed (both aerial photograph analysis and field investigations) and not so detailed (based mainly on satellite pictures/aerial photographs). It is still under construction and being tested (tests done in summer 2002, Jönköping County Administrative Board 2002b), but it will be a good tool to get more basic data for each lake. A conform knowledge of the same basic data for each lake will be a good starting-point for the monitoring. Next to the walking along the lake shore (as for watercourses) it can be possible to first make an inventory from a boat and chose parts that have to be inventoried more detailed, as ditches, watercourses, etc. (since these parts can not be seen from a boat). Due to the analysis of aerial photographs, the emergent vegetation can be partly investigated too (see method description). One difficulty is that the density of vegetation changes strongly during the summer months (Jönköping County Administrative Board 2002b). Overall it seems that the inventory of vegetation is the largest problem when using this method and it should be investigated which vegetation parameters are better covered by a specific macrophyte inventory. (For method description see Jönköping County Administrative Board 2000b)

Aerial photographs (black-white and IR)
The analysis of aerial pictures can give information on the emergent and floating-leaved vegetation and the structure of the shore and anthropogenic influences on it, as well as the land-use in the surrounding. Further can be decided, by using aerial photos, where fieldwork (as for example macrophyte inventories) will be necessary. It should be noticed that aerial photographs are expensive and therefore will not be done specifically for Natura 2000 reasons. They are done for several purposes in a county, but this does not happen regularly, today around every tenth year in the County of Jönköping.

Aerial photographs are very detailed, even small and complicated objects can often be seen. The analysis is work-intensive (manual interpretation and drawing), but the technique is easy, and not very special material is needed. Today, aerial photos are not more expensive than satellite pictures, but they often are more cost-effective. And the most interesting part along a watercourse, the nearest 30 m, is not sufficiently seen on a satellite picture. This method is not very suitable for the analysis of small lakes and watercourses.

Two kinds of films are possible to use:
1) <u>Black-and-white:</u> very detailed (sharp), both easy access to 1:30 000 and 1:60 000.
2) <u>IR:</u> important for the analysis of different types of vegetation, access can be difficult sometimes, especially in the same scale. Updating not very regularly done (expensive). Today often old, from the 1980ies, new pictures are expensive. A solution is to use black-and-white pictures and field-investigations for the vegetation monitoring.

In general, on pictures of a scale 1:30 000 1*1 m large objects are visible, for the identification they have to be 2-3 times larger (car, small houses, if not covered). To be able to identify an object of the size 2*2 m (truck), pictures in a scale of 1:60 000 are necessary. Due to the technique, measuring is not possible on these pictures, or very difficult.

What can be seen on aerial photographs:
<u>Vegetation and land-use:</u> rough classification of the lakeshore environments is possible. Different types of forest management (clear cutting, plantations, sly, etc.) can be seen on both films. However, the difference between coniferous, deciduous and mixed forest and between

used forest and natural forest requires a specialist for black-and-white pictures. With IR, even several types of wetlands and freshwater vegetation can be seen. By this, different types of vegetation, as grasses, reeds and floating-leaved vegetation, and many different species can be recognised. Submersed vegetation is very difficult, if not impossible, and special pictures are necessary (1:5000/1:10 000).
Buildings: There is no great difference between the films; black-and-white films are sometimes even better, since they are sharper. The size of the objects is important. 1*1m difficult to get, since 1:10 000 is only accessible for densely populated areas. With 1:30 000/60 000 (2-3m) still possible: small cottages, bridges, smaller streets, and boathouses, depending on the material. Streets can almost always be seen, even if they are partly covered. Tractor-roads (vegetated, in forests) and small paths can be sometimes difficult to identify.
Lakeshore type: at least 1:30 000 is necessary, for IR 1:60 000 is also possible, but difficult. Different kinds of strands can be identified (stone-, rock-, sand- and gravel-strand, grass- and earth-strand, wetland-strand).
Water depth and bottom type: Sometimes possible, but difficult. The kind of film is unimportant, at least 1:30 000 is necessary.

Further, stream type and fluvial forms and constructions and other anthropogenic interventions can be analysed. (For the method description see Granath 1997)

Satellite pictures
They are not very useful for the monitoring of most lakes and watercourses, since the results are not detailed enough (20*20m/10*10m resolution is best accessible, classification possible for 120*120m/60*60m). Positive: automatically analysis (half-automatically classification) possible. (For the method description see Granath 1997)

Metals in freshwater mosses (Fontinalis) (BIN V R21)
Measuring the amount and composition of metal in mosses (for the method description, see SEPA 1986).

Sediment chemistry
The sediment chemistry is mostly investigates in lakes, since there is too much sediment transport in watercourses. To get to know the pollution grade of the sediment and the pollution of a recipient. Measured are the water content, organic content, totN, oils and metals. At least 3 sampling points are necessary (in the running programs usually one point in the deepest place of the lake). Recommended is every fifth to tenth year at fix points. (For the method description see SEPA 1986)

Otter
There is no standard method available for monitoring otter. The organisation 'Föreningen Rädda Uttern i Småland' makes inventories and collects information from the public about sights of otter or its traces (Föreningen Rädda Uttern i Småland 1995).

Birds
There does not exist a standardised method for monitoring birds, but information can be used that is given by

- 'Hotartregister' (database of the County)
- 21 Standard routes within the County, which do not cover Natura 2000 sites
- Monitoring by ornithology-societies (no standard method)
- National database/inventory (method, University of Lund)

- (Internet: Bird watching system for rare birds 'Svalan')

Water level/flow
The water flow (and level) of the larger watercourses is often measured, for example at the hydropower and meteorological stations, but it can be calculated too (SMHI-modelling). The water level of lakes is usually not measured so much. There exist different types of water-level gauges (water level scale with graduation, marked water level scale, automatically registering water-level gauge that saves or sends the values) and it has to be proved which type is most suitable for the Natura 2000 purposes. A suggested frequency could be every week in march/april and july/august.

Nostoc zetterstedtii
N. zetterstedtii is monitored normally by use of water scope on suitable bottoms or by tugging a net box on the lake bottom behind a boat. Snorkelling is also a suitable and fast method. For the future, video will be a great help. The monitoring can – with some extra expenses – be included in the submersed macrophyte monitoring. (For the method description see Bengtsson 1996)

Echo-counting of pelagic fish
This method will be suitable for large lakes, where the water column is too large for using nets to get sufficient data on the fish populations (as for example Lake Vättern). Another reason could be to use this method for rare fish species as *Salvelinus umbla* and its prey fish. This method is most suitable for getting to know the size of fish populations, but it will not give the different fish species, unless samples of them are taken too.

Further...
For example are standard methods missing for water related insects, bats, and salamander/amphibians.

7.3. Standard methods of the Water Framework Directive

For the monitoring of elements named in the Water Framework Directive, methods shall be used that conform to international standards, or any other national or international standards that will ensure the provision of data of an equivalent scientific quality and comparability. Standards exist for macro-invertebrate sampling and for physicochemical and hydromorphological parameters, but for macrophyte, fish and diatom sampling they have to be developed (WFD, Annex V: Surface water status, Standards for monitoring of quality elements).

Sampling frequency
For surveillance monitoring the minimum frequency for physical-chemical factors is every third month. Biological and hydromorphological factors shall be monitored at least once every sixth year. For operational monitoring, the frequency shall be chosen in that way, that a reliable assessment of the status can be done. Statistically this includes that an acceptable confidence-level and accuracy shall be reached and that the influence of seasonal variations shall be as small as possible. Prioritised substances shall be monitored each month. (WFD, Annex V)

7.4. Method overview (table), including general costs and frequencies

Table 13. *Methods, including costs and frequencies*

Method	***Lakes***		***Watercourses***	
	Costs (total, for calculations see Appendix 2)	**Frequency times/year (optimal - minimum) (and no of investigation places) as in the method description**	**Costs (total, for calculations see Appendix 2)**	**Frequency times/year (optimal - minimum) (and no of investigation places) as in the method description**
Elements covered by standard methods from the handbook				
Water quality	Analysis 1050 SEK/sample[1]	12/1 - 1/6	Analysis 1050 SEK/analysis[1]	12/1 – 1/1
Water quality/metals	Analysis 800 SEK/sample[1]	[2]	Analysis 800 SEK[1]	[2]
Phytoplankton	Analysis 2000 SEK/sample[1]	1/2nd week – 1/1	---	---
Periphyton (diatoms)	---	---	Ca 5000 SEK/sample	At least 1/1
Submersed macrophytes in lakes/Macrophytes in watercourses (incl., if relevant, mosses, macro algae, Nostoc)	3360 SEK/transect	1/1 – 1/5	7000 SEK/100 m^2	1/1 – 1/5 (minimum 100 m^2)
Emergent and floating-leaved macrophytes (and mosses) in lakes (aerial photos)	235 SEK/km shore length[3]	ca 1/10	---	---
Littoral fauna	4800 SEK[3]	12/1 - 1/5	---	---
Profundal fauna	6500 SEK[3]	2/1 – 1/5	---	---
Benthic fauna	---	---	4500 SEK[3]	12/1 – 1/5
Gillnet fishing/Electro-fishing	1200 SEK/net (incl. all)	1/1 – 1/3 (No of nets depend on the size of the lake)	2600 SEK/place[3]	1/1 (at least three places per watercourse)
Freshwater mussels	---	---		
Crayfish	170 SEK/trap (incl. all)	No of traps depend on the size of the lake	170 SEK/trap (incl. all)	(No of traps depend on the size of the lake)
Metals in fish	[2]	[2]	[2]	[2]
Site description	Included in the other monitoring	Combined with other sampling	Included in the other monitoring	Combined with other sampling
Elements covered by other methods than standard methods from the handbook				
Habitat survey	2700 SEK/km	Ca 1/10	2700 SEK/km	Ca 1/10
Aerial photo analysis	235 SEK/km shore length[3]	When aerial photographs are available (ca 1/10)	---	---
Sediment chemistry	Analysis 2000 SEK/sample (only metals: 1200)	---	---	---
Echo counting of pelagic fish	12 200/transect	[2]	---	---
Water-level and –flow	Difficult, see method description and discussion			
Metals in freshwater mosses				

1: plus sampling costs (can be co-ordinated, see Appendix): 1750 SEK (average for lakes), 385 SEK (average for watercourses) + 50 SEK for postage; 2: depending very much on the aim (supplementary level); 3: consult price

8. Case study in the County of Jönköping, final monitoring suggestion and cost calculations

8.1. Summary of the case study and the outcomes

The analysis of the Natura 2000 freshwater sites in the County of Jönköping (see Appendix 4) has been done catchment area wise, to answer the tasks of the Water Framework Directive for water management, where all management plans will be done catchment area-wise and the Natura 2000 areas have to be registered in each river basin. Catchment areas are the natural unit when classifying freshwater habitats, not only because of the natural conditions but especially also due to the kind of effecting influences. The County of Jönköping is subdivided into nine catchment areas, whereof seven include the 53 freshwater Natura 2000 sites within the county (see Appendix 4). The catchment areas of the rivers Emån and Lagan cover the largest parts of the county and at the same time more than half of the Natura 2000 lakes, ponds and watercourses.

The monitoring analysis for Natura 2000 lakes and watercourses in the County of Jönköping includes seven of the eight Swedish freshwater habitat types that go into the Natura 2000 network. For most of the habitat types there can be found good (as in a meaning for average) examples in this county. However, Lake Vättern for the habitat types of hard oligo-mesotrophic lakes respectively Lake Draven for the habitat type of eutrophic lakes are not very good examples to get a typical picture of these habitat types in Sweden. Lake Vättern is the second largest lake of Sweden and has very special monitoring needs due to its unique size and economic value. It is only partly considered in the case study, since it has a complex monitoring program. Lake Draven is a restored lake with very special conditions. It was tried to give anyway a more general monitoring suggestion at the end.

During the case study, general conditions, actual threats, and existing monitoring (parameters and frequencies) were investigated. The Natura 2000 lakes and watercourses in the County of Jönköping are mainly surrounded by forest and a smaller part mires and agricultural used land. It has been shown that most of the Natura 2000 lakes, especially the dystrophic lakes and ponds in mires, lie in the beginning of catchment areas. There is no dangerous industry situated around, so that there is no great danger for influences of polluting substances others than the ones coming from agriculture and forestry. The size of the protected habitats differs widely. Just a few lakes are only partly protected.

Since the existing monitoring programs differ strongly between single sites, it is difficult to generalise the existing information. When looking only on the elements water quality, phytoplankton and benthic fauna, 63% (23 out of 36) of the sites that include Natura 2000 lakes and ponds habitats have no running monitoring (or so long frequencies as 1/10), and of these ones are 11 sites (48%) dystrophic lakes and ponds. Only two lakes have a monitoring of all three parameters water quality, phytoplankton and invertebrates. Habitat survey has been done for 4 (out of 36) lakes and vegetation monitoring will be new for all sites. On the other hand, of all watercourses (14) are only two not subject to running monitoring at all, and only three have not been investigated by habitat survey.

42% (22 of 53) of the lakes and watercourses are parts of larger Natura 2000 areas including terrestrial habitats too. As it is shown in figure 1, the oligo- and oligo-mesotrophic lakes are mostly only protected by themselves, whereas the dystrophic ponds and lakes lie very often within mires that are Natura sites as a whole. The sites with the Natura 2000 habitat 'watercourses of plain to montane level' are mainly very small and also included in larger Natura 2000 areas. Of these 22 Natura 2000 sites, including other habitat types as Western Taiga, Transition mires and quaking bogs, etc., 18 have a Swedish protection status (nature reserve, national park, etc.) today (see figure 2).

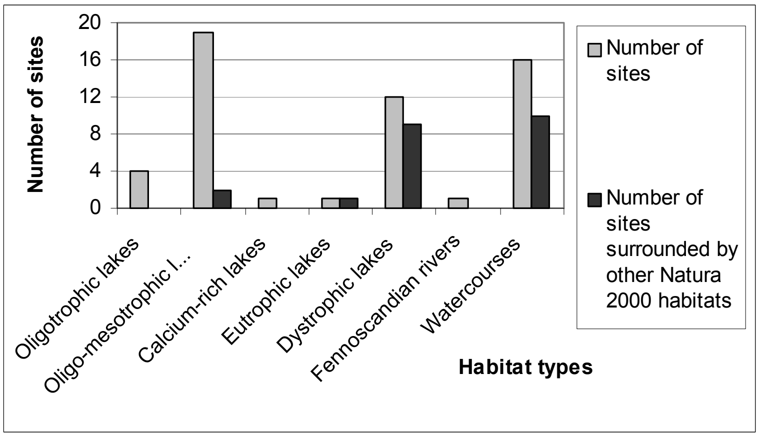

Figure 1. Integration into terrestrial Natura 2000 habitats

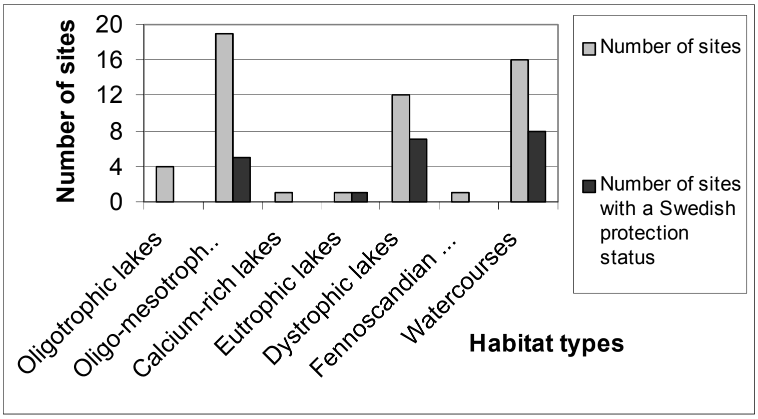

***Figure 2.** Lakes and watercourses that have a Swedish protection status*

When a site has a 'traditional' (Swedish) protection status or is surrounded by other Natura 2000 habitats, there are not so many negative influences (as agriculture, forestry, buildings at the strandline) on the freshwater habitat. On the other hand, effects of for example leisure activities can have a stronger impact. For lakes and watercourses with other surrounding (terrestrial) Natura 2000 habitats, there will automatically be a monitoring of the surrounding. Otherwise, the monitoring of a lake or a watercourse has to include the surrounding and its land-use too.

Next to the lake itself, one thing to consider but difficult and costly to monitor, are the in- and out-flowing watercourses and their catchment areas. They have an important role considering e.g. the incoming nutrients, pesticides, toxic substances, and suspended material. By monitoring a lake, it can be necessary to detect the source of a specific pollution and than the monitoring of the catchment area will be necessary on a supplementary level. The outflows of a lake will be important to monitor due to the migration ways and possible barriers and water level regulation, e.g. hydropower stations.

Concerning the monitoring of watercourses, it will be very important, due to the natural conditions, to monitor not only the protected part of the river itself, instead everything what happens in the whole area upstream that area (the catchment area) will have an influence on the Natura 2000 site.

8.2. Final monitoring suggestion

Being aware of the fact that there are many possibilities of combining the discussed parameters and methods and the results of the analysis of the specific sites in the County of Jönköping, a general monitoring suggestion on a basic level for the lakes (see table 14) and watercourses (see table 15) is made anyway. Notable is that for four lake habitat types the monitoring suggestion is the same, but for the dystrophic lakes it is different, as is results from the evaluation of parameters, methods and the case study. The supplementary level will depend very strongly on the actual threat situation, some possible parameters are listed in table 16.

Table 14. *Suggestion for the monitoring on a basic level for lakes*

Element	Oligo-, oligo-meso-, calcium rich-, and eutrophic lakes	Dystrophic lakes
Habitat survey (lake)	1/12	(1/12)
Only remote sensing (Aerial photo analysis (incl. emergent and floating leaved macrophytes (and mosses))	---	Ca 1/10
Water quality	1/1	1/6
Phytoplankton	1/1	1/6
Submersed macrophytes (and mosses)	1/6	---
Emergent and floating vegetation (field)		(1/6)
Littoral fauna, respectively profundal fauna	1/3	1/6
Gillnet fishing	1/6	
(Water level)		
Site description	(with each sampling)	

Table 15. *Suggestion for the monitoring on a basic level for watercourses*

Element	Frequency
Habitat survey (watercourse)	1/12
Water quality	12/1
Macrophytes (and moss) in watercourses (typical species)	1/6
Electro-fishing (typical species)	1/3
Benthic fauna	1/3
(Water-level/flow)	
Site description	(with each sampling)

Table 16. *Possible monitoring parameters on a supplementary level*

Lakes	Watercourses
Element of the basic level more frequent	Element of the basic level more frequent
Sediment chemistry	Water quality/metals
Profundal fauna	Crayfish
Water quality/metals	Periphyton
Periphyton	Freshwater mussels (typical species)
Nostoc (indicator, rare species)	Birds (typical species)
Bird (typical species)	Metals in fish
Amphibians (e.g. salamander typical species)	
Bats (typical species)	
(Submersed/Emergent vegetation)	
(Gillnet fishing)	
Zooplankton	
Water-level	

8.3. Application on the freshwater habitats in the County of Jönköping

The presented final monitoring suggestion for Natura 2000 lakes and watercourses has been exemplified on the habitats in the County of Jönköping. By applying the general monitoring suggestions on these sites, existing monitoring was considered (normal style in table 17). When this was not sufficient, additional monitoring parameters and/or frequencies were added (bold style in table 17).

Table 27. *Existing and additional suggested monitoring (bold) for the freshwater habitats in the County of Jönköping*

Site name	Habitat survey/Aerial photo analysis incl. emergent veg.	Water chemistry	Phytoplankton	Benthic fauna	Fishing	Vegetation
Oligotrophic lakes						
Vallsjön	**1/12**	2/1	1/1	1/3	**1/6**	**1/6**
Södra Vixen	**1/12**	2/1	1/1	1/3	**1/6**	**1/6**
Hindsen	**1/12**	3/1	1/1	1/3	1/5	**1/6**
Kansjön	in 2002	**1/1**	**1/1**	**1/3**	**1/6**	**1/6**
Oligotrophic to mesotrophic lakes						
Lindåsasjön	**1/12**	1/5 **4/5**	**1/1**	**1/3**	**1/6**	**1/6**
Försjön (Eksjö)	**1/12**	**1/1**	**1/1**	**1/3**	**1/6**	**1/6**
Mycklaflon	**1/12**	2/1	1/1	1/3	**1/6**	**1/6**
Vrången	**1/12**	3/1	**1/1**	**1/3**	1/10 **1/10**	**1/6**
Fjärasjö	**1/12**	4/1	1/1	1/1	1/3	**1/6**
Färgsjö	**1/12**	**1/1**	**1/1**	**1/3**	**1/6**	**1/6**
Övingen	**1/12**	**1/1**	**1/1**	**1/3**	1/10 **1/10**	**1/6**
Drängagråten	**1/12**	**1/1**	**1/1**	**1/3**	**1/6**	**1/6**
Assjön	**1/12**	1/5	**1/1**	**1/3**	**1/6**	**1/6**
Bordsjön	In 2002	**1/1**	**1/1**	**1/3**	**1/6**	**1/6**
Illern	In 2002	**1/1**	**1/1**	**1/3**	**1/6**	**1/6**
Sötåsasjön	**1/12**	1/5	**1/1**	1/5	**1/6**	**1/6**
Försjön (Aneby)	**1/12**	1/5	**1/1**	**1/3**	**1/6**	**1/6**
Strånnesjön	In 2002	**1/1**	**1/1**	**1/3**	**1/6**	**1/6**
(Vättern)[1]						
Rödsjön	**1/12**	**1/1**	**1/1**	**1/3**	[2]	**1/6**
Ören	**1/12**	2/1	1/1	**1/3**	**1/6**	**1/6**
Strandgölen	**1/12**	**1/1**	**1/1**	**1/3**	[2]	**1/6**
Fegen	**1/12**	1/1	1/3	1/3	**1/6**	**1/6**
Hard oligo-mesotrophic lakes						
(Vättern)[1]						
Eutrophic lakes						
Draven	**1/12**	12/1	-	-	-	**1/6**
Dystrophic lakes						
Kakelugnsmossen	**1/10**	**1/6**	**1/6**	**1/6**	-	
Stora och Lilla Fly	**1/10**	**1/6**	**1/6**	**1/6**	-	
Hökatorp	**1/10**	**1/6**	**1/6**	**1/6**	-	
Svartahål	**1/10**	**1/6**	**1/6**	**1/6**	-	

Store Mosse - Kalvasjön	**1/10**	1/5	**1/6**	1/5	-	
Store Mosse - Kävsjön	**1/10**	**1/6**	**1/6**	**1/6**	-	
Mossjön	**1/10**	4/1	1/1	1/1	1/3	
Bottnaryds Urskog	**1/10**	**1/6**	**1/6**	**1/6**	-	
Dumme Mosse	**1/10**	**1/6**	**1/6**	**1/6**	-	
Bottenlösen	**1/10**	**1/6**	**1/6**	**1/6**	-	
Gållsjön	**1/10**	**1/6**	**1/6**	**1/6**	-	
Bare Mosse	**1/10**	**1/6**	**1/6**	**1/6**	-	
Kråketorpsskogen	**1/10**	**1/6**	**1/6**	**1/6**	-	
Fennoscandian watercourses						
Emån	exists	exists		exists	exists	**1/6**
Watercourses of plain to montane level						
(Emån and Illharjen)						
Gnyltån	exists	exists		exists	exists	**1/6**
Solgenån	exists	exists		exists	**1/3**	**1/6**
Allmänningsån	exists	**12/1**		**1/3**	**1/3**	**1/6**
Sällevadsån	exists	exists		exists	exists	**1/6**
Fuseån	exists	exists		exists	**1/3**	**1/6**
Silverån	exists	exists		exists	**1/3**	**1/6**
Hålebäcken	**1/12**	exists		exists	**1/3**	**1/6**
Storkvarnaån	**1/12**	**12/1**		exists	exists	**1/6**
Årån	**1/12**	exists		exists	exists	**1/6**
Domneån	exists	exists		exists	**1/3**	**1/6**
Gagnån	exists	exists		exists	exists	**1/6**
Holmån	exists	**12/1**		**1/3**	**1/3**	**1/6**
Röttleån/Vestanå	exists	exists		exists	exists	**1/6**

1: Lake Vättern has been excluded from the results, since the monitoring of this lake is too complex to be considered due to the purpose of this study; 2: introduction of fish because of fishing activities

8.4. Cost calculations

Based on the exemplification of the monitoring suggestion for Natura 2000 lakes and watercourses on the habitats in the County of Jönköping, the total costs could be calculated (calculations see Appendix 3). Further more, existing monitoring has been proved if it would be sufficient and the results were taken into account when calculating the adjusted costs for the county, which means the costs without existing monitoring programs. These programs are for example meant for the follow-up of liming activities and discharge from industries or to get regional or national reference values. The financing is done by other specific sources. It will be assumed that the existing monitoring of the relevant sampling stations will be continued in the future.

Most of the method descriptions give estimations about the material costs and the working time (see table 13). However, to be able to calculate costs for the monitoring on the suggested basic level, it was necessary to be more precise here, though knowing that these costs can vary strongly. The basic data for the cost calculations are presented in table 13 and in Appendix 2 and 3. For the calculations, average costs for the monitoring were used, since the existing frequencies are very variable, the finance sources differ widely (wherefore the costs can be different), the frequencies can be denser, and coordination of different projects can lower the costs strongly. It was tried to meet average numbers, not only for the cost calculations for the county, but also to give the possibility to transfer these numbers to other areas. It was decided to count the costs for a period of six years, to get the range of the whole monitoring of one reporting period.

The results show that the total costs of the suggested program, transferred to the County of Jönköping, are around 4,65 million SEK for a period of six years (see figure 3). These costs are lower than half, when existing monitoring is considered. The total yearly costs will then be 375 000 SEK.

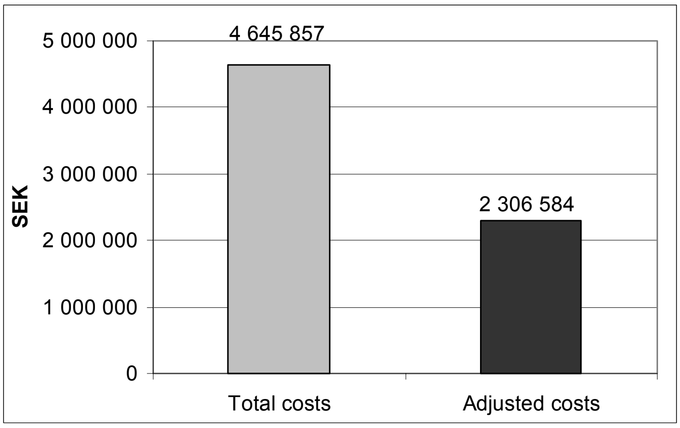

Figure 3. *Total and adjusted costs for the monitoring of freshwater Natura 2000 sites in the County of Jönköping (6 year period)*

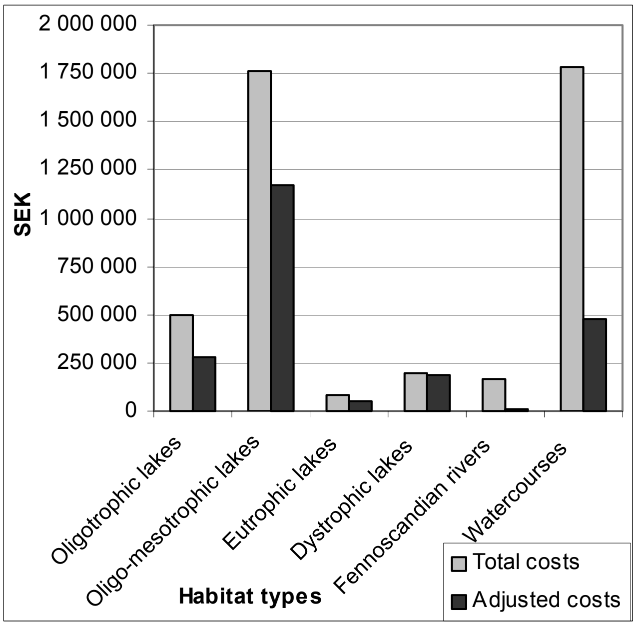

Figure 4. *Total and adjusted costs for the different habitat types (6 year period)*

Figure 4 shows the costs separated on to the different habitat types in the county. The results should be compared with the number of sites per habitat type in the county (see figure 1 and/or 2). The oligo-mesotrophic lakes and the watercourses of plain to montane level are as well the most ones and the most expensive ones in the county. Remarkable is that the high number of dystrophic lakes and ponds have very low costs. This is because of the lower monitoring frequency, and that aerial photograph analysis is used instead of the habitat survey as for the other sites. The average costs for an oligotrophic, oligo-mesotrophic, or eutrophic lake are around 117 000 SEK, for a dystrophic lake about 17 000 SEK, and for a watercourse 137 000 SEK (all numbers are given for a 6-year period).

Comparing the costs of the different elements (see figure 5), the monitoring of the water quality is the most expensive one. One explanation is the high frequencies (12/1) for the watercourses. Sampling costs are included for the water quality, whereas for the monitoring of phytoplankton only the analysis costs were calculated. This results from the fact that the monitoring of these parameters can be easily combined. Otherwise the costs for the phytoplankton would be much higher. There is no existing monitoring of the

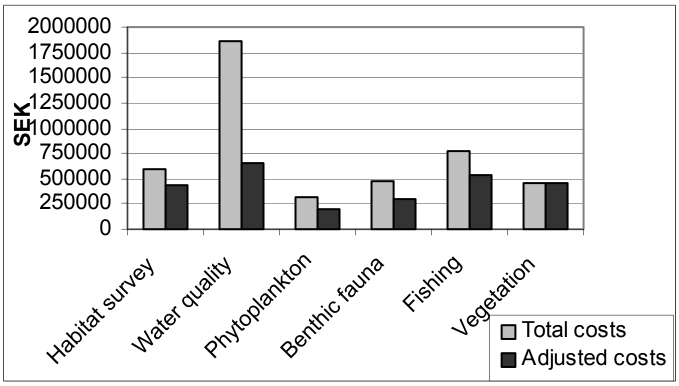

Figure 5. *Costs for the different elements (6 year period)*

freshwater vegetation in the Natura 2000 lakes and watercourses in the County of Jönköping, as it can be seen also in figure 5.

9. Synthesis and Conclusions

9.1. Monitoring – general considerations

The monitoring analysis of Natura 2000 freshwater habitats in the County of Jönköping shows that all sites have very different preconditions due to specific conditions and threats, and that some lakes and watercourses have no existing monitoring and others have varying monitoring. Some sites are national reference lakes and watercourses with a running monitoring of certain parameters (as mostly water quality, phytoplankton, fishes, and invertebrates) since a long time, and some do not even appear in the lake register of the county (as small ponds). Some sites have been protected, when there was no incentive to monitor them. But the opinion that protected lakes and watercourses should be included in monitoring programs becomes stronger. Now with the Habitats Directive (and the Water Framework Directive) it is required on a national level by the EU. The lakes and watercourses were chosen to be included into the Natura 2000 network because of their high biological value. During the analysis of 54 Natura 2000 sites it appeared that (almost) each site has negative influences, and therefore requires being subject to monitoring.

The national and EU descriptions of the habitat types are not enough to characterise a site, regional differences can make two oligotrophic lakes be more different, as for example Lake Vättern (1910 km^2, own monitoring program) and the pond Drängagråten (< 1 km^2, once investigated because of its *Triturus cristatus* population), than the difference between the habitat types oligo- and oligo-mesotrophic for example is. The sites could be classified due to similar monitoring needs: surrounded by agriculture and/or forestry, threatened by eutrophication and/or acidification, or ponds in mosses, watercourses with large parts in urban areas, lakes without surface in- and outflow, etc. The variability can be larger within habitat types than between them when it comes to monitoring needs. Since the monitoring needs are dependent more on the threats than on the habitat type, the threats are decisive in what monitoring to do.

Thinking of a wider context and the possibility to transfer the outcomes of this analysis to other parts of the country, it shows that many aspects are very regional and there will be a difference when monitoring a lake in ‘the middle of nowhere’ in the Northern part of Sweden, as when monitoring a lake in Scania, surrounded by agricultural used and urban area. The differences will be not only the adequate parameters, but also the adequate frequencies.

It will be necessary to get a basic knowledge of the sites, if this does not yet exist, for monitoring in the long run. The costs only for getting a basic knowledge about the sites that have not had an aerial photograph analysis and/or a field survey, will be 865 000 SEK for the freshwater sites in the County of Jönköping. Important factors will be for example a documentation of shoreline, land-use in the surrounding and other influences. It makes a difference if a site is surrounded by protected habitats or not, as the influences of the land-use, e.g. agriculture, will be less and a coordinated monitoring with other Natura 2000 habitat types can be done too. Generally, protected freshwater habitats should always include a protected buffer zone too (as every lake or watercourse – protected or not - should have a

buffer zone). It has been shown by the existing data of the watercourses in the County of Jönköping, that the Natura 2000 watercourses lack buffer zones on long distances.
When beginning monitoring the Natura 2000 lakes and watercourses, it will be useful to check existing monitoring and assure it for the future, as well as data of time-series. For watercourses this can also mean that even if an existing monitoring point is relatively far away from the site (downstream), its value for the site can be very strong. It will be important to consider how many tributaries flow into the watercourse downstream of the site, when estimating if this point can give sufficient data for the monitoring. By monitoring freshwater habitats, the in- and outflowing watercourses are very important. It is important not only to monitor the site itself instead the catchment/tributaries too, when there are affecting activities in the catchment area.

For the habitat type 'Alpine rivers and the herbaceous vegetation along their banks', an example is missing in the County of Jönköping. But as it has been shown, the differences between the parameters of the other two watercourse types are not strong, and probably they could, with minor adjustments, be transferred to the third watercourse habitat type too.

Conclusions:
- There is a high variability between the (threats and conditions of) different sites, regardless of the habitat type
- It is important to consider if a site lies in a protected surrounding
- There is a high variability between the (amount and frequency of) existing monitoring of different sites. 64% of all Natura 2000 lakes in the County of Jönköping have no running monitoring (in most cases dystrophic lakes), and 14% of all watercourse sites
- A core of basic information for all sites is needed in the beginning of the monitoring, in 34 of 50 cases this is missing, the costs for this would be 865 000 SEK

9.2. Parameters

The choice of parameters shall be orientated on the aim of the monitoring: the investigation if a site has its 'favourable conservation status'. It seems that the parameters do not differ so much between different habitat types of lakes respectively watercourses, than much more depend on the regional circumstances of a specific site.

The basic parameters are for example water quality, phytoplankton (only lakes), land-use in the surrounding area, influences on the near surrounding (as industries, dumps, golf courses, etc.), vegetation, fishes, buffer zones, introduction of non-native species, benthic fauna, and bottom substrate. It is important to detect negative influences on the favourable conservation status at an early state. Some parameters, as buffer zones, will have their meaning of preventing the water from threats or, as the kind of land-use, to be aware of possible reasons for negative changes, as for example high nutrient loads. The water quality is different for every habitat type, as the hard oligo- and mesotrophic lakes and the eutrophic lakes are well buffered; the oligotrophic lakes have low and the eutrophic lakes high loads of nutrients. But the water quality can differ between different sites too, as for example when agriculture in the surrounding exists or not.

It will not be realistic to monitor the water quality as often as it would be necessary for detection of all kinds of changes, and some changes can be missed by measuring only the water quality, as the ones, that occur only periodically or once. Therefore, other parameters have to be considered. Parameters are needed that can give a good picture of the whole situation and that can make it possible to detect changes. The water quality method covers also only the basic chemical parameters, metals are quite expensive, and several parameters are missing at all (many different and partly unknown toxic substances, as pesticides). It will probably be most (cost) effective, to monitor sensitive species that reflect dangerous changes fast (bioindicators).

For indicating long-term changes in eutrophication and acidification, phytoplankton/periphyton, benthic invertebrate and plant species communities are of importance. Invertebrates, periphyton, and macrophytes can work as bioindicators particularly in watercourses. The monitoring of phytoplankton (and zooplankton) communities is not suitable in these habitats, because they are continuously transported downstream from monitored sites. The list of typical species includes very few examples of invertebrates, even though their indicator value is widely accepted.

Because Natura 2000 freshwater habitat types are mainly characterised by their vegetation, monitoring of the vegetation community (or vegetation zones and/or depth distribution) can be an important tool for detection of environmental changes in these habitats. Regarding monitoring aspects, the vegetation community can be considered as two ‘groups’, submersed and emergent/floating vegetation. For eutrophic lakes, the typical species are emergent or floating macrophytes, but the best indicator for changes of the water quality will be the submersed macrophytes, since they will react faster on changes in the light climate. On the other hand, in the habitat types oligotrophic, oligo-mesotrophic and hard oligo-mesotrophic lakes, which are characterised by submersed vegetation, the development of floating and emergent vegetation will probably be a good indicator for environmental changes too.

To point up how difficult the evaluation of different indicators is, concerning which one could be the best or if it could be possible to use only one indicator, a choice of studies shall be presented shortly. It has also been shown that the values of different indicators can be regionally different. Kelly and Whitton (1998) have been investigating the indicator value of macrophytes and phytoplankton for eutrophication of watercourses and they point out that the influences vary strongly (as varying uptake of nutrients from the sediment) and make the classification difficult. Melzer (1999) studied the macrophytes in the littoral of 100 lakes (e.g. the large lake Chiemsee) and resumed that macrophytes are useful indicators of water pollution. However, he showed also that regional differences make different indexes for different regions necessary. Triest et al. (2001) investigated diatoms, macro-invertebrates and macrophytes as indices in Belgium, and considered that these elements are complementary for monitoring of biological quality and the ecological status of a river system.

Specific species of fish are only named as typical species for certain habitats (as the oligo-mesotrophic and the eutrophic lakes). Like the macrophytes, the monitoring of them will also make sense in other habitat types, because of their indicator value (as e.g. for the oligotrophic lakes).

In dystrophic lakes and ponds, submersed plants and fishes will probably have a minor role as bioindicators. These lakes differ widely from the other types of lakes. Forest and/or mires mostly surround them, often occur quagmires. Dystrophic lakes are characterised by floating and emergent vegetation. The open water surface can be relatively small. The light climate is controlled not by the production of phytoplankton, but of the input of humic organic matter that gives the water a characteristic brown colour.

There is often very little knowledge about the lake shore/riparian zone of the protected lakes and watercourses. This information is very important to determining the existing state of the habitat and to observe for example the need for conservation measures (buffer zones, migration barriers). The shoreline is a part of the lake or river (even if it does not go into the protected site) and one of the most important influencing factors on the state in the lake (shadowing, dead tree and leaves – biomass and nutrients, habitat for fauna and flora). Migration barriers and fragmentation can make the exchange of organisms impossible and will therefore make the ecosystem of that lake very sensible (no recolonization, inbreeding).

For several vegetation types a natural variation of the water level in a lake/watercourse is necessary. Most of the Natura 2000 lakes and watercourses in the County of Jönköping are regulated and have therefore not a natural water level fluctuation. When a dam exists at the outflow of a lake, it will be unnecessary to start intensive (and expensive) monitoring by setting water gauges. It will be more realistic to monitor indicator species that show water level disturbances and stress, as for example ephemerophytes. Organisms that are not able to move when the conditions are not favourable any longer and therefore die out in extreme cases, will be the best indicators. Invertebrates for example will just move and return when the conditions are better again.

The typical species are of course different for the different habitat types. But since they will mostly be monitored as groups (all submersed plants, all fishes) the differences in the monitoring will not be so strong. Additionally, Natura 2000 species (Annex 2 and 4) and red-listed species will be part of the monitoring of the habitat types. Species that have a special problematic (e.g. *Nostoc zetterstedtii*), or a special meaning due to their long-term use as indicators (e.g. crayfish and freshwater pearl mussel) in the County of Jönköping shall be used further on. Many Natura 2000 species in one site could be a measurement for a good favourable conservation status.

Natura 2000 sites that are (also) chosen because of their special value for birds (Special Protected Areas, SPA, Birds Directive), as the national park Store Mosse, the nature reserve Dumme Mosse and the Lake Draven will require a special consideration of monitoring the birds.

The parameters and monitoring on the suggested basic monitoring level are fixed, whereas the ones on supplementary level will change, depending on the situation and problems. Many of the basic parameters are already included in running monitoring programs. Generally, the same parameters are on a basic respectively supplementary level for all habitat types, differing slightly between lakes and watercourses. However, the choice of parameters from the supplementary level will depend strongly on the actual situation. It could be a strategy to monitor influencing parameters (as land-use) only on a supplementary level (after negative changes occurred), as e.g. checking for buffer zones when the nutrient loads became too high. But it is more effective, for biological as well as for economical reasons, to detect changes in an early state, as measure costs will be less when the measures are not so many.

Conclusions:

- ***Basic parameters are water quality, phytoplankton (only lakes), land-use in the surrounding area, influences on the near surrounding (as industries, dumps, golf courses, etc.), vegetation, fishes, buffer zones, introduction of non-native species, benthic fauna, bottom substrate, etc***

- ***The basic parameters for all lake habitat types are generally very similar, except for dystrophic lakes***
- ***The basic parameters are for both watercourse habitats the same.***
- ***Many of the basic parameters are included in already running monitoring programs***
- ***There will have to be a prioritisation on the monitoring of several species, especially the typical ones, as it is not realistic to monitor all of them (the Annex species will have/require their own monitoring programs).***
- ***Important and endangered species like otter or freshwater pearl mussels have to be included in the habitat monitoring when they occur in the specific site (which often was selected because of the species)***
- ***Bioindicators have an very important meaning***

9.3. Methods

For monitoring the different habitat types of the Natura 2000 lakes and watercourses, it seems that in general the same methods can be used for all lake-types and watercourses. There are not many cases where the methods are different for the same parameter of different habitat types, as for vegetation. But, methods can be different for lakes and watercourses (gillnet- or electro-fishing) and also due to different sizes of lakes, as Lake Vättern requires specific monitoring as satellite monitoring and echo-counting. It can happen that the same method covers several parameters as for example habitat survey and aerial photograph analysis. On the other hand, one parameter can be covered by several methods, e.g. emergent and floating vegetation or some influences on the shore can be monitored by aerial photograph analysis or by field investigations.

a) Existing methods in the handbook
The existing, standardised monitoring methods from the 'Handbook for Environmental Monitoring' (SEPA 2002i) cover most of the basic parameters, as water quality, fishing, phytoplankton, and benthic fauna. The methods have also already been used in the County of Jönköping. Sometimes they offer several ambition levels and it was possible to choose one of these. But for some parameters even the minimum version of the monitoring method is unrealistic in terms of frequencies and number of investigated places for the Natura 2000 purposes, as for electro fishing. Even though the species differ between the different habitat types, they will in general require the same methods. Macrophyte species will be monitored by the vegetation method (submersed or emergent), fish species due to the fishing methods, etc.

Compared to other methods from the handbook, which have been widely used before, the monitoring of freshwater vegetation has so far not been done as a running program on a regional level. However, both the Habitats Directive and the Water Framework Directive will require macrophyte monitoring. A standardised method for submersed vegetation of lakes and the vegetation of watercourses has now been published. Furthermore, a method for the monitoring of emergent and floating-leaved vegetation is in work and will soon be published in the handbook too. Several LIFE-projects aim to test existing methods and develop new ones, when necessary. One approach is for example to monitor the lowest vegetation line at the lake bottoms to detect changes in the water quality (Spiess & Bolbrinker 2001). The problem is that these methods include a very frequent monitoring that is possible for the analysis of one lake, but probably not for the monitoring for ten-thousands of lakes and watercourses in the EU. Current methods for monitoring vegetation may therefore require adjustment before they are applied in water management in EU (as there are required standard methods for the WFD).

Submersed macrophytes require specific monitoring, while the emergent and free-floating respective floating-leaved vegetation can be investigated generally using the aerial photograph analysis (as it is also included in the habitat survey) and during the submersed vegetation monitoring. For monitoring submersed vegetation there are different possibilities, diving, video, use of water scope, and sampling from boat. Diving is a very expensive method (it requires for example three people) and in most cases not cost efficient. Most Swedish lakes have a low Secchi depth due to humic particles. As a result, the submersed vegetation does not grow very deep. For large lakes as Vättern (and Mycklaflon) with deep and clear water and many submersed plants, diving can be suitable, as well as video monitoring. The sampling method will generally give insufficient information on the vegetation zones and means also a disturbance of the plant community.

Due to the intensive aspects of the vegetation method, it will most likely not be realistic to initialise a (yearly) running monitoring program for all sites. The suggestion is to use a rotating system, so that every lake is done once in six (or 12) years. The minimum frequency of not less than three years seems unrealistic for the purposes of Natura 2000. It could also be possible and covering the needs for the favourable conservation status to choose some sites for a continuously running monitoring program (also for getting reference values) and have it as an additional aim to make vegetation monitoring of the other sites once in a 6 or 12 year-reporting period. More vegetation inventories in these specific habitat types of Natura 2000 will also give more knowledge about this element and will make it easier to formulate objectives. With more investigation it will also be easier to know in which lakes it is worth to continue the vegetation monitoring frequently and in which ones random sampling will be enough (1/6, 1/12).

One special problem is dystrophic ponds that are very small and lie often within bog areas, sometimes totally surrounded by quagmires. This can make it impossible to reach the water. The sampling of water for the monitoring of the quality and the phytoplankton can in many cases only be done with the help of helicopters. There are also not so many submersed plants after the quagmire ended since the water can be deep already and the light not enough. If monitoring with a water scope is not possible, due to the bog and/or the quagmire, sampling will be the only way. Not every pond will have to be investigated, a choice of pond(s) should be done for each side.

b) Additional parameter-covering methods that are not in the handbook
For most of the parameters not covered by methods from the handbook, as e.g. buffer zones, water level/flow, structure of the shore/riparian zone, there exist several widely accepted methods.

To get information on the lake shore/riparian zone, buffer zones, migration barriers, fragmentation grade and the land-use in the surrounding area, aerial photographs and satellite pictures do not show all the details that are needed, especially for smaller watercourse they are not suitable. Parameters as for example the bottom substrate will be missed. The access to IR pictures (especially on one scale) is difficult and taking new pictures very expensive. On the other hand, from black-and white photographs it will not be possible to analyse all important details. The solution could be to combine aerial photograph analyses with field investigations, as it is done due to the monitoring concept 'habitat survey'. However, for dystrophic ponds that lie in mires and/or are partly covered by quagmires, this method will not be appropriate, since the method requires for example walking along the shoreline. But these habitats are also not influenced so much, wherefore a monitoring of aerial pictures can be enough in most cases. It then will also cover the monitoring of the emergent and floating vegetation. Additionally, data from the field should be collected. Following up the Water Framework Directive, it will also be necessary to develop (or standardise) methods for monitoring hydromorphological elements and the strand structure.

There are several ways to measure the water flow in watercourses. For the catchment of Emån, a project is initialised now, to measure the water flow at several stations of the tributaries and the main flow. A lack of monitoring seems to be the knowledge about the water level of lakes. It will not be realistic (and not be necessary and effective in a cost-benefit point of view either) to initialise water-level gauges at every single lake. Especially not for ones that are strongly affected by water regulation or water outtake (drinking, irrigation). It is a suggestion to set a water-level gauge at some lakes that are not regulated. For regulated lakes, the monitoring of the water level will mean to only observe if regulations exist and how strong the influence on the habitat is (indicators). After all, it will be most cost effective, to take care that especially in the oligo-mesotrophic lakes with annual vegetation, a natural water level fluctuation occurs, the measuring will then not be so necessary.

c) Still existing lacks/problems

Methods for the basic parameters, except the water level, exist. Periphyton could not be included in the suggested monitoring program, since the analysis is very difficult and only a few specialists can do it. Typical species as bats, birds, amphibians, insects, and otter have not been used very much in earlier monitoring programs and there exist no standard methods for them. However, these species groups will get an importance when they are also Natura 2000 species or red-listed or when they are used for defining the monitoring objectives.

All methods shall consider follow up possibilities for regional communities, which do not require a frequent monitoring.

Conclusions:

- ***Generally, the methods for specific parameters are the same for the different habitat types of lakes (except dystrophic lakes) respectively watercourses***
- ***The chosen methods and parameters have almost all been used in monitoring programs in the County of Jönköping before, but vegetation monitoring for example not***
- ***Methods for the basic level exist, except for the water level. All except one are standard methods***
- ***The method/concept 'habitat survey' will be added to the chore of handbook-methods, to add an instrument for collecting basic information to start monitoring (choice of places for other monitoring) and for parameters not covered by standard methods (as buffer zone, vegetation cover, substrate). This method has to be more tested and improved***
- ***Aerial photograph analysis will be important; when possible, habitat survey should be preferred before aerial photograph analysis, since it includes, additionally to the remote sensing, field survey***
- ***Sometimes, only some parts/levels have to be used of one method***
- ***The vegetation and periphyton method have to be improved to fit to the purposes of Natura 2000 (and the Water Framework Directive)***

- ***Typical species groups like macrophytes and fishes are more suitable for the monitoring than for example bats and birds, both from a biological and methodological point of view***
- ***There have to be found possibilities to monitor the water level of lakes in an effective way (for unregulated lakes), as also the Water Framework Directive could require this***
- ***Standard methods are missing for a number of species, as for birds in common, but also for some specific fish species that are not covered by the existing standard methods***

9.4. Frequencies

It has been shown that the existing frequencies can vary strongly due to different programs for different sites. For Natura 2000 sites, mainly the minimum frequencies of the methods were chosen, because of the often low pressure of external influences. The suggested methods include often several levels of monitoring frequencies. But in many cases even the minimum level seems to be too intensive for a monitoring of protected habitats in a cost-benefit point of view. Protected habitats are often not so strongly affected by anthropogenic factors; especially when the direct surrounding is part of the protected area too. The monitoring on the basic level can vary from several times every year (e.g. water quality in watercourses every month), once or more often during the reporting period (as for example macrophyte and invertebrate investigations), to once in 12 years, as aerial photograph analysis and habitat survey for more constant parameters (as roads, migration barriers, water regulations).

It has to be considered that the monitoring will have to be done much more intensive in the beginning, especially when a monitoring parameter is investigated for the first time at one site. This can vary very much (depending on earlier monitoring programs and the threat situation). The frequency for the supplementary level is pointless to estimate, it is the character of this level to be used when needed. Therefore, only a cost calculation for the basic level has been done. For the future it will be required to coordinate/harmonise the frequencies of running monitoring programs with the tasks by Natura 2000.

Conclusions:
- A higher frequency will be needed in the beginning, as also basic information is needed on several sites
- Frequencies have to be coordinated due to the different kinds of purposes

9.5. Monitoring, and then?

a) Objectives and/or assessment instruments (Environmental Quality Criteria)
It is not possible to keep the favourable conservation status of a site, when there is not enough detailed information about what this is. Measurable objectives for the Natura 2000 habitats/sites have to be formulated (SEPA 2002g) and for this, more information on the characteristics of the habitat types are necessary. Using objectives, it shall be possible to describe the difference between acceptable and unacceptable conditions (Brown 2001), as well for a site (regional) as for a habitat type (national level). The quality objectives will/can be different for every site, as each habitat/site must have specific objectives. To get a formulated standard for monitoring, as the wanted state or condition for each of the protected features on the site, we must be clear about:
- which features/parameters (for species and habitats) we want to conserve, and
- for each feature/parameter, the condition we want to achieve (Brown 2001).

Two values shall be given for each parameter: one for defining a 'stable level' (recovery limit) and one for defining the lowest acceptable level for the favourable conservation status (Brown 2001; SEPA 2002g).
The objectives have to consider national and regional aspects for a habitat in good condition, but also local individuality and the presence of other features in the same site. A standard that can be applied to a large geographical area can miss local variability. On the other hand, some local aspects may be unwelcome and represent only poor habitat condition (Brown 2001). The conservation plans of each site shall include formulations of the measurable quality objective and the favourable conservation status for the habitats, their vegetation, other organism communities and certain additional species. These objectives and this status are the ones that shall be followed up (SEPA 2002g).

The objectives have to be aware of the natural succession of the habitats as being biological systems. An example for how quality objectives for the favourable conservation status for fennoscandian natural watercourses can look like is: the length of this habitat, that salmon can reproduce in sustainable populations, and that at least 20% of the Freshwater pearl mussels are shorter than 5 cm, and individuals shorter than 2 cm occur. For dystrophic lakes, the objectives could be the size of the habitat, the occurrence of natural water level variations during the whole year and that freshwater organisms can migrate between the lakes and ponds (SEPA 2002g).

To get to know if a measured parameter tells whether a favourable conservation status exists or not, and when there are no clearly formulated objectives (yet), the measured data have to be analysed. This can be done in two ways:
1) When previous data about the site exist (which should have been measured in a comparable way), these should be used as 'comparable values'.
2) If the previous data are not sufficient or do not exist yet, the national 'Environmental Quality Criteria' for lakes and watercourses can be used for comparison respectively to get information about measured values. These quality criteria make it possible to assess environmental quality on the basis of available data and by this obtain a better basis for management by objectives (SEPA 2000a). The status of freshwater areas by physical and chemical factors such as nutrients/eutrophication, oxygen levels and oxygen-consuming substances, visibility, acidity/acidification and metals can be assessed. It is also possible to assess biological conditions in form of species balance and quantities of phytoplankton (only in lakes), freshwater plants (only in lakes), periphyton (diatoms) (only in watercourses), benthic macroinvertebrates and fishes. The quality criteria are meant to be used for data gathered in accordance with the instructions in the Environmental Monitoring Handbook (SEPA 2002i). It will be necessary to develop quality criteria for macrophytes in watercourses, since these do not exist yet. It can be also a solution to include the two values named before ('stable level' and 'lowest acceptable level for the favourable conservation status').

The quality criteria are updated right now and adapted to the needs of the Water Framework Directive (Sedin & Reinholdson 2000). It is a question if quality criteria are really needed when the monitoring of Natura 2000 sites is only directed to clearly formulated, site specific objectives. But these do not exist yet and the quality criteria can be a help in the process of formulating the objectives. They can further be a help for monitored parameters that do not have a well defined objective.

b) Handling of data

The monitoring outcomes of Natura 2000 should be collected in a database. It will be good to have the data on each site collected at one place to easily compare results with earlier data, to be able to formulate conservation objectives and get a better knowledge about the habitat types. Existing data registers, as DMN, are not running properly. Maybe the handling of data could follow the data received through the WFD.

Conclusions

- ***There is a need for a Natura 2000 monitoring database***

9.6. Cost Analysis and economical discussion

After suggesting the monitoring program for the Natura 2000 freshwater sites, the costs resulting from this have been calculated for the County of Jönköping. The elements water quality, phytoplankton, vegetation, fishes, benthic invertebrates, and habitat survey/aerial photograph analysis have been considered. A minimum frequency was chosen.

By including existing monitoring programs, the costs can be lowered by more than half. The adjusted costs of 375 000 SEK per year for monitoring all Natura 2000 lakes and watercourses in the County of Jönköping due to the suggested program should be seen in relation to others. Compared to some other expenses of our community, this amount seems to be rather small. It means that we will be able to know what changes are going on in protected areas, which got this status because of their value and importance to the whole European Community. Balmford et al. (2002) reviewed several studies concerning the values of intact ecosystems and estimated that the overall benefit : cost ratio of an effective program for the conservation of remaining wild nature is at least 100:1. However, looking on the costs from the view of the environmental monitoring department of the County Administrative Board in Jönköping, these costs will have no finance. On the other hand, the SEPA pays for the monitoring of Lake Vättern the same amount as the monitoring of all Natura 2000 lakes and watercourses in the County of Jönköping would cost, and that is only a part of the whole program. The total costs for the monitoring program of the catchment area of Lake Vättern are ca. 2,3 million SEK/year (Vätternvårdsförbund 2001).

The results of these calculations can be a help for the future work and discussion on the financial aspects of Natura 2000.

Several factors can influence the costs strongly:

- Coordination of the running monitoring programs makes many monitoring parameters much more cost-efficient.
- The size of a lake/watercourse.
- It was only slightly considered that the monitoring will have to be done much more intensive in the beginning, since this will depend very much on the financial possibilities. But there will have to be a denser monitoring during the first time.
- The monitoring will not only get less frequent (if no changes occur that make monitoring on a supplementary level important) during running monitoring, but some methods will also be able to be carried out in a shorter time after a while, since existing knowledge and data can be used (for example the choice of investigation places has to be done only once).

Conclusions:

- ***The total costs for the County of Jönköping are calculated to be 775 000 SEK/year for the suggested monitoring program, including water quality, phytoplankton, vegetation, fishes, benthic invertebrates, and habitat survey/aerial photograph analysis***
- ***Taking existing monitoring in account, the adjusted costs for the program will be 375 000 SEK/year***
- ***The yearly average costs for an oligotrophic, oligo-mesotrophic or eutrophic lake are calculated to be 19 500 SEK, for a dystrophic lake 2833 SEK and for a watercourse 22 833 SEK.***
- ***Additional costs will be for the analysis and evaluation of data, and monitoring of species (e.g. freshwater pearl mussel)***
- ***Coordination of methods can keep the costs low (as for example water and phytoplankton sampling at the same time)***

9.7. Concluding thoughts about the combination of the goals of Natura 2000, the Water Framework Directive and the National Environmental Objectives

Harmonising the tasks for a 'favourable conservation status' (Natura 2000), a 'good ecological status' (Water Framework Directive) and an 'ecological sustainability' (national Environmental Objective) of freshwater habitats in Sweden

There will be new monitoring tasks because of the Water Framework Directive and the National Environmental Objectives. These new programs can also be integrated with the Natura 2000. The WFD includes specifically the aspect of monitoring protected areas, and it will have to be discussed if this can cover the monitoring of Natura 2000 lakes and watercourses or if there shall be a specific monitoring due to the Habitat or Birds Directive itself, as it is practised in Sweden and for example in Germany too. As the Environmental Agency in Bristol formulates, when the continuously running monitoring of the Natura 2000 sites shows that there appears a certain pressure that is liable to cause a failure to achieve the objective of the protected area, the Water Framework Directives requires that the water is monitored by the relevant program until the relevant objective is achieved (Environmental Agency 2002). On the other hand, Finland decided to wait for the monitoring program of the WFD, and not to work on a specific Natura 2000 freshwater monitoring (J. Abenius, 03.10.2002 personal communication). However, monitoring due to the WFD will have its own finance, organised by water fees/charges (Svenskt vatten 2002).

The monitoring due to Natura 2000 can give information that could be used for regional follow up of the national Environmental Objectives. This could be a reason for co-financing the monitoring. However, monitoring due to the National Environmental Objectives will most likely not have any extra financial support outside what is currently provided. Both the regional objectives and the objectives of Natura 2000 will require an increase of existing monitoring of lakes and watercourses in the County of Jönköping. The national Environmental Objectives include a lot of 'shall' formulations and are themselves not legally binding. The regional objectives are more detailed. They are a 'tool' for analysing of and reporting on the national Environmental Objectives. The difference between the objectives of the WFD and the national ones is that the objectives from the WFD will be specific and clear norms (which have to be reached) for example to proof if the ecological status of surface waters exists.

Comparison with the state in other countries
The work on the monitoring of Natura 2000 freshwater habitats is very similar in many countries. English Nature has, in conjunction with the other UK Conservation Agencies, developed a monitoring program designed for the Natura 2000 areas. This site condition monitoring includes, as relevant to the objective of the specific site, for freshwater habitats plants (e.g. slender naiad), invertebrates (e.g. freshwater pearl mussel), fishes (e.g. salmon), amphibians (e.g. great-crested newt), birds (e.g. osprey), and mammals (e.g. otter). Monitoring of physical and chemical elements is carried out to complement biological monitoring. Conservation objectives have been developed for each site and now a monitoring program is developed for each site to ascertain whether these objectives are being met (Environment Agency 2002).
Germany has like Sweden a project group to work on this task. The discussion on possible parameters/indicators and methods goes on. A suggestion of quality criteria for the favourable conservation status of freshwater habitats, based mainly on macrophyte species, is used in several Bundesländer now (LÖBF 2002).

General conclusions:

- ***Generally, not only the lake/watercourse should be protected, but as well the immediate surrounding should be included too***
- ***The conservation plans for the Natura 2000 sites shall have measurable objectives***
- ***The monitoring has to be adapted to the conservation plans***
- ***Assessment instruments are needed***
- ***Nature conservation measures will require extra monitoring (not considered in this report), as well as Natura 2000 Annex species***
- ***There will be additionally costs for the monitoring, but these costs will not only cover the needs of the Natura 2000 directives, further they will cover the tasks of the WFD and the Environmental Quality Objectives. This means also that the costs can be covered from different sources.***
- ***The monitoring programs will not differ as much between specific habitat types as much more depend on the regional conditions and threats (nutrients and pesticides from agriculture, forestry management, acidification).***
- ***Coordination between different countries can be a help, since all EU member states have the same tasks***
- ***The monitoring of the Natura 2000 freshwater sites will give more knowledge about these habitats in Sweden***

Outlook/Future aspects:
What kind of intensity the basic monitoring level will have has not been decided yet. It can be randomised for the whole country and include a few sites of every habitat type (landscape level) or it can be on a regional (habitat) level, where each site is followed up (SEPA 2002b). The first one will probably be the strategy for the whole country (as discussed on the national seminar for monitoring freshwater habitats, 03-10-2002), and the second could be a regional possibility for the counties. The national monitoring will then observe the ‘trends’ of the habitat types in whole Sweden and not the status of each site.

The work on the monitoring of Natura 2000 freshwater habitats will from now and during the next year include the set up of goals and objectives/assessment instruments and the work on a database and a national strategy report, including also the role of the counties. Further, the work on the Water Framework Directive will continue and the monitoring has to be coordinated with the work on Natura 2000.

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Appendix 1

Indicator values of freshwater macrophyte species

	3110	3130	3140	3150	3160	3210	3260	Indicates:[1]	Indicator value[2]
Submersed macrophytes/isoetids									
Isoetes echinospora	x	x						oligotrophic	4
Subularia aquatica	x							oligotrophic	4
Isoetes lacustris	x	x						oligotrophic	5
Lobelia dortmanna	x							oligotrophic	5
Ranunculus reptans		x						oligotrophic-indifferent	5,3
Pilularia globulifera		x						meso-oligotrophic	5,5
Elatine hydropiper		x						mesotrophic/eutrophic	6
Littorella uniflora	x							mesotrophic	6,7
Submersed macrophytes/elodeids/nymphaeids									
Potamogeton polygonifolius	x	x						meso-oligotrophic	3
Sparganium angustifolium							x	meso-oligotrophic	3
Utricularia minor					x			oligotrophic	4
Potamogeton alpinum/s							x	mesotrophic-indiff.	5,5
Ranunculus peltatus							x	mesotrophic	8,5
Ranunculus trichophyllus							x	eutrophic	8,5
Stratiotes aloides				x				eutrophic	9
Ceratophyllum demersum				x				eutrophic	10
Myriophyllum verticillatum							x	eutrophic	10
Najas marina			x						10
Potamogeton filiformis			x					eutrophic	10
Elatine triandra		x						semi-eutrophic	
Ranunculus fluitans							x	eutrophic	/
Floating-leaved macrophytes									
Potamogeton natans				x				indifferent	6,7
Nuphar lutea				x				eutrophic	8,5
Persicaria amphibia/um							x	semi-eutrophic	9
Lemnids									
Lemna minor				x				eutrophic	8,5
Hydrocharis morsus-ranae				x				eu-mesotrophic	9
Spirodela polyrrhiza				x				eutrophic	10
Helophytes and others									
Carex rostrata					x			indifferent	4,3
Carex lasiocarpa					x			oligotrophic	5,5
Cinna latifolia						x			
Myricaria germanica						x			
Rhynchospora alba					x			oligotrophic	
Sagittaria natans x sagittifolia						x		semi-eutrophic	(/) (9)
Salix daphnoides						x			

Salix lapponum						x			
Salix triandra						x			
Sparganium glomeratum						x			
Taraxacum crocodes						x			

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Appendix 2

Cost calculations/prices (when no consult price was available)

General costs for the calculations
Employees: 300 SEK/h (incl. social contributions) (1 day = 8 h office/10 h field)
Allowance for expenses: 10 h/d in the field = 75 SEK, >10 h/d in the field = 150 SEK/d
car: 350 SEK/100 km (in one day approximately 300 km possible
More than 50 km away from Jönköping: sleeping place costs have to be added (ca 200 SEK/night/person) (similar with driving back to Jönköping for the night)
Evaluation and reporting costs are not counted

Sampling costs (Water chemistry/phytoplankton lakes)
Lakes are in average around 60 km away from the City Jönköping. For water and phytoplankton sampling, the following costs have to be considered (estimating that four lakes can be investigated in one day):
employees: 2* (10 h/field day * 300 SEK/h + allowance for expenses as 150 SEK/d (10 h field)) = 6300 SEK
car: 200 km/d * 3,5 SEK/km = 700 SEK
sum: 7000 SEK/4 = 1750/lake
plus analyse costs (incl. postage) of water quality: 1050 SEK
total sum: 2800 SEK

Water chemistry/watercourses
sampling: 10 sampling stations/day
1 person: 10h/d *300 SEK/h + allowance for expenses as 150 SEK/d = 3150 SEK
sum: 385 SEK/sampling station
sum incl. analyse costs (1050): 1435 SEK/sampling station

Submersed vegetation
Numbers from earlier projects financed by SEPA (Berta Andersson, personal communication, 12-09-2002)
Investigation in four lakes in the upper Northern part of Sweden (lakes difficult to reach): 75 000 SEK, as this is 18 750 SEK/lake
Investigations in six lakes in Småland and Västmanland: 70 000, as this is 11 667 SEK/lake
(I checked this numbers with the costs used for the County of Jönköping:
2 delomraden: 1 day á 2 people = 20 h a 300 SEK + 2*150 SEK (allowance for expenses) + 120 km* 3,5 SEK (car) (+ sleeping place) = 6720 SEK/2 transects; as it is for one transect 3360 SEK. Since not very much is known about the numbers of transects per lake, I estimate an average number of 3 transects per lake, even if this will vary very strongly in reality.

Vegetation in watercourses
100 m^2/day (first time), later 200 m^2/day, travel time, evaluation; minimum 100 squares
1½ day/site
car: 200 km * 3,5 SEK/km = 700 SEK
employees: 2* (10 h/field day * 300 SEK/h + allowance for expenses as 150 SEK/d (10 h field)) = 6300 SEK
sum: 7000 SEK

Habitat survey
2700 SEK/km shore length (for watercourses this includes both sides), number from earlier projects and calculations
(lakes: one person on the shore, one in the water. Watercourses: One on each side of the watercourse)
For the cost tables for each habitat, the costs were divided by 2, to get the frequency of twelfth years to six.

Remote sensing (aerial photographing) Analysis time ca 10 km shore/h; 3-4 transects per day; 235 SEK/km shore length

Appendix 3

Monitoring costs for the lakes and ponds in the County of Jönköping, due to the suggested monitoring program (calculations for six years)

	Habitat survey/Aerial photo analysis incl. emergent veg.	Water chemistry	Phytoplankton	Benthic fauna	Fishing	Submersed vegetation (+ emergent and floating)
Oligotrophic lakes						
Vallsjön	**23 085**	16 800	12 300	9600	48 000	11 000
Södra Vixen	**24 165**	16 800	12 300	9600	48 000	11 000
Hindsen	**71 145**	16 800	12 300	9600	48 000	11 000
Kansjön	**4995**	16 800	12 300	9600	28 800	11 000
sum	123 390	67 200	49 200	38400	172 800	44 000
Oligo-mesotrophic lakes						
Lindåsasjön	**7 155**	16 800	12 300	9600	28 800	14 000
Försjön (Eksjö)	**22 140**	16 800	12 300	9600	57 600	14 000
Mycklaflon	**37 530**	16 800	12 300	9600	67 200	14 000
Vrången	**18 765**	16 800	12 300	9600	38 400	14 000
Fjärasjö	**4 455**	16 800	12 300	9600	19 200	14 000
Färgsjö	**2 000**	16 800	12 300	9600	19 200	14 000
Övingen	**21 195**	16 800	12 300	9600	48 000	14 000
Drängagråten	**1350**	16 800	12 300	9600	[1]	[2]
Assjön	**20 655**	16 800	12 300	9600	57 600	14 000
Bordsjön	**4 860**	16 800	12 300	9600	19 200	14 000
Illern	**5 940**	16 800	12 300	9600	19 200	14 000
Sötåsasjön	**13 635**	16 800	12 300	9600	38 400	14 000
Försjön (Aneby)	**14 985**	16 800	12 300	9600	48 000	14 000
Strånnesjön	**4860**	16 800	12 300	9600	9 600	14 000
(Vättern)						
Rödsjön	**1350**	16 800	12 300	9600	[3]	14 000
Ören	**45 360**	16 800	12 300	9600	57 600	14 000
Strandgölen	**1350**	16 800	12 300	9600	[3]	14 000
Fegen	**71 145**	16 800	12 300	9600		14 000
sum	298 730	302 400	221 400	172800	528 000	238 000
Eutrophic lakes						
Draven	**12 150**	16 800	12 300	9600	19 200	14 000
sum	**12 150**	16 800	12 300	9600	19 200	14 000
Dystrophic lakes						
Kakelugnsmossen	118	2 800	2 050	11 300		
Stora och Lilla Fly	118	2 800	2 050	11 300		
Hökatorp	118	2 800	2 050	11 300		
Svartahål	118	2 800	2 050	11 300		
Store Mosse (2)	2115	5 600	2 050	11 300		
Mossjön	541	2 800	2 050	11 300		
Bottnaryds Urskog	118	2 800	2 050	11 300		
Dumme Mosse	118	2 800	2 050	11 300		

Bottenlösen	118	2 800	2 050	11 300		
Gållsjön	118	2 800	2 050	11 300		
Bare Mosse	118	2 800	2 050	11 300		
Kråketorpsskogen	118	2 800	2 050	11 300		
sum	3836	36 400	24 600	135 600		

Monitoring costs for the lakes and ponds in the County of Jönköping, due to the suggested monitoring program, but in regard to existing monitoring programs (calculations for 6 years)

	Habitat survey/Aerial photo analysis incl. emergent veg.	*Water chemistry*	*Phytoplankton*	*Benthic fauna*	*Fishing*	Submersed vegetation (+ emergent and floating)
Oligotrophic lakes						
Vallsjön	23 085	0	0	0	48 000	11 000
Södra Vixen	24 165	0	0	0	48 000	11 000
Hindsen	71 145	0	0	0	0	11 000
Kansjön	0	16 800	12 300	9 600	28 800	11 000
sum	118 395	16 800	12 300	9 600	124 800	44 000
Oligo-mesotrophic lakes						
Lindåsasjön	7 155	13 440	12 300	9 600	28 800	14 000
Försjön (Eksjö)	22 140	16 800	12 300	9 600	57 600	14 000
Mycklaflon	37 530	0	0	0	67 200	14 000
Vrången	18 765	0	12 300	9 600	15 360	14 000
Fjärasjö	4 455	0	0	0	0	14 000
Färgsjö	2 000	16 800	12 300	9 600	19 200	14 000
Övingen	21 195	16 800	12 300	9 600	19 200	14 000
Drängagråten	1350	16 800	12 300	9 600		
Assjön	20 655	14 000	12 300	9 600	57 600	14 000
Bordsjön	0	16 800	12 300	9 600	19 200	14 000
Illern	0	16 800	12 300	9 600	19 200	14 000
Sötåsasjön	13 635	13 440	12 300	3 840	38 400	14 000
Försjön (Aneby)	14 985	0	0	0	0	14 000
Strånnesjön	0	16 800	12 300	9 600	9 600	14 000
(Vättern)						
Rödsjön	1350	16 800	12 300	9 600		14 000
Ören	45 360	0	0	9 600	57 600	14 000
Strandgölen	1350	16 800	12 300	9 600		14 000
Fegen	71 145	0	0	0		14 000
sum	283 070	192 080	159 900	128 640	408 960	238 000
Eutrophic lakes						
Draven	12 150	0	12 300			14 000
sum	12 150	0	12 300			14 000
Dystrophic lakes						
Kakelugnsmossen	118	2 800	2 050	11 300		
Stora och Lilla Fly	118	2 800	2 050	11 300		
Hökatorp	118	2 800	2 050	11 300		
Svartahål	118	2 800	2 050	11 300		
Store Mosse (2)	2115	2 800	2 050	11 300		
Mossjön	541	0	0	0		
Bottnaryds Urskog	118	2 800	2 050	11 300		
Dumme Mosse	118	2 800	2 050	11 300		
Bottenlösen	118	2 800	2 050	11 300		

Gållsjön	*118*	*2 800*	*2 050*	*11 300*		
Bare Mosse	*118*	*2 800*	*2 050*	*11 300*		
Kråketorpsskogen	*118*	*2 800*	*2 050*	*11 300*		
sum	*3836*	*30 800*	*22 550*	*124 300*		

Monitoring costs for the watercourses in the County of Jönköping, due to the suggested monitoring program and in regard to existing monitoring programs (calculations for 6 years)

	Habitat survey	*Habitat survey incl. existing monitoring*	Water chemistry	*Water chemistry incl. existing monitoring*	Benthic fauna	*Benthic fauna incl. existing monitoring*	Fishing	*Fishing incl. existing monitoring*	Macrophytes
Fennoscandian watercourses (3210)									
Emån	47 250	0	103 320	*0*	9000	*0*	5000	*0*	11 000
sum	47 250	0	103 320	*0*	9000	*0*	5000	*0*	11 000
Watercourses of plain to montane level (3260)									
(Emån)									
(Illharjen)									
(Stora Illharjen)									
Gnyltån	18 900	0	103 320	*0*	9000	*0*	5000	*0*	11 000
Solgenån	1 080	0	103 320	*0*	9000	*0*	5000	*5000*	11 000
Allmänningsån	1 485	0	103 320	103 320	9000	*9000*	5000	*5000*	11 000
Sällevadsån	9 180	0	103 320	*0*	9000	*0*	5000	*0*	11 000
Silverån	20 250	0	103 320	*0*	9000	*0*	5000	*5000*	11 000
Fuseån	35 100	0	103 320	*0*	9000	*0*	5000	*5000*	11 000
Helvetets Håla	513	513	103 320	*0*	9000	*0*	5000	*0*	11 000
Årån	11 880	11 880	103 320	103 320	9000	*0*	5000	*0*	11 000
Vikskvarn	2 700	2 700	103 320	103 320	9000	*0*	5000	*0*	11 000
Domneån	932	0	103 320	0	9000	*0*	5000	*5000*	11 000
Gagnån	10 125	0	103 320	*0*	9000	*0*	5000	*0*	11 000
Holmån	2 430	0	103 320	103 320	9000	*9000*	5000	*5000*	11 000
Västanå	1 836	0	103 320	0	9000	*0*	5000	*0*	11 000
sum	116 411	15 093	1 343 160	*413 280*	117000	*18000*	65000	*30000*	143 000

Appendix 4

Case study – Natura 2000 lakes and watercourses in the County of Jönköping

Freshwater Natura 2000 habitats in the County of Jönköping (= also Special Protected Area (SPA) by the Birds Directive)(numbers: lakes and areas with ponds, letters: watercourses)*

a1) Catchment area of the river Emån (main stream)	
1 Vallsjön	Oligotrophic lakes
2 Södra Vixen	Oligotrophic lakes
3 Lindåsasjön	Oligotrophic lakes
4 Försjön (Eksjö)	Oligo-mesotrophic lakes
5 Mycklaflon	Oligo-mesotrophic lakes
6 Vrången	Oligo-mesotrophic lakes
7Kakelugnsmossen/ponds	Natural dystrophic lakes
A Emån (western part)	Fennoscandian watercourses
B Emån (western part)	Watercourses of plain to mont.
CIllharjen (part of Emån)	Watercourses of plain to mont.
D Stora Illharjen ("-")	Watercourses of plain to mont.
E Gnyltån	Watercourses of plain to mont.
F Solgenån	Watercourses of plain to mont.
G Allmänningsån	Watercourses of plain to mont.
H Sällevadsån	Watercourses of plain to mont.
J Fuseån	Watercourses of plain to mont.
a2) *Catchment area of the river Emån - north*	
8 Fjärasjö	Oligo-mesotrophic lakes
I Silverån (norra)	Watercourses of plain to mont.
a3) *Catchment area of the river Emån - south*	
9 Färgsjömon (Färgsjö)	Oligo-mesotrophic lakes
10 Stora och Lilla Fly (ponds)	Natural dystrophic lakes
11 Hökatorp (ponds)	Natural dystrophic lakes
12 Svarta håls vildmark/ponds	Natural dystrophic lakes
M Helvetets håla (Hålebäcken)	Watercourses of plain to mont.
b) Catchment area of the river Lagan	
13 Hindsen	Oligotrophic lakes
14 Övingen	Oligo-mesotrophic lakes
15 Draven*	Natural eutrophic lakes
16 Store mosse* (ponds)	Natural dystrophic lakes
17 Mossjön	Natural dystrophic lakes
N Årån	Watercourses of plain to mont.
OVikskvarn/Storkvarnaån	Watercourses of plain to mo.
c) Catchment area of the river Svartån	
18 Drängagråten	Oligo-mesotrophic lakes
19 Assjön	Oligo-mesotrophic lakes
20 Bordsjön	Oligo-mesotrophic lakes
21 Illern	Oligo-mesotrophic lakes
22 Sötåsasjön	Oligo-mesotrophic lakes
23 Försjön (Aneby)	Oligo-mesotrophic lakes
24 Strånnesjön	Oligo-mesotrophic lakes
d) Catchment area of the river Göta älv	
25 Bottnaryds urskog/pond	Natural dystrophic lakes
e) Catchment area of the river Motala (Vättern)	
26 Kansjön	Oligotrophic lakes
27 Vättern (södra)	(Hard) oligotrophic to mesotro.
28 Rödsjön	Oligo-mesotrophic lakes
29 Strandgölen	Oligo-mesotrophic lakes
30 Ören	Oligo-mesotrophic lakes
31 Dumme mosse* (ponds)	Natural dystrophic lakes
32 Bottenlösen	Natural dystrophic lakes
33 Gållsjön	Natural dystrophic lakes
34 Bare mosse* (ponds)	Natural dystrophic lakes
P Domneån	Watercourses of plain to mont.
Q Gagnån	Watercourses of plain to mont.
R Holmån	Watercourses of plain to mont.
S Västanå/Röttleån	Watercourses of plain to mont.
f) Catchment area of the river Ätran	
35 Fegen*	Oligo-mesotrophic lakes
g) Catchment area of the river Mörrumsån	
36Kråketorpsskogen/ponds	Natural dystrophic lakes

a1) Emån (main stream)

Oligotrophic waters containing very few minerals of sandy plains (Littorelletalia uniflorae) (3110)

Lake	*Area km²*	*Depth (max/average) m*	*Retention time a*	*Volume 1 000 000 m³*	*Catchment km²*	*Shore length km*
1 Vallsjön	7,07	17/5	4	37,6	25,4	17,1
2 Södra Vixen	5,1	17/5,9	8,28	30,1	14,4	17,9

The lakes Södra Vixen (11 tributaries) and Vallsjön (relatively large amount of agriculture around) are surrounded by forest- and agricultural used land, they are only protected themselves, without the surrounding habitats. Both lakes are not within a special sensitive area for acidification. Specific threats are eutrophication and drainage/ditching. Migration barriers occur for both lakes downstream. Vallsjön is regulated. Since the lakes lie almost at the very beginning of the catchment (and there is no dangerous industry situated around), there is no great danger for influences of polluting substances others than the ones coming from

Birds Directive	*Pandion haliaetus*	In both lakes
	Gavia arctica	In both lakes
Further	*Nostoc zetterstedtii*	In both lakes

agriculture and forestry. Though loads of nutrients and particles have to be observed carefully.

Oligotrophic to mesotrophic standing waters with vegetation of the littorelletea uniflorae and/or of the Isoeto-Nanojuncetea (3130)

Lake	***Area km²***	***Depth (max/average)***	***Retention time a***	***Volume 1.000.000 m³***	***Catchment km²***	***Shore-length km***
3 Lindåsasjön	0,74	14/5,1	4,41	3,75	3,8	5,3
4 Försjön (Eksjö)	2,582	27/8,8	5,98	23,6	17,9	16,4
5 Mycklaflon	11,53	40,5/12,6	8,26	145	85,6	27,8
6 Vrången	1,8	12,5/3,9	3,77	6,49	8,4	13,9

The lakes Vrången (no inflows), Försjön (Eksjö) and Mycklaflon (12 inflows) are surrounded mainly by forest (small part agriculture) whereas Lindåsasjön (2 inflows) has a relatively large proportion of agriculture around. There is a threat of general forestry management, drainage/ditching and eutrophication. All four lakes are not surrounded by other protected areas, and are not within easily acidified areas. Migration barrier occur with the outflow/downstream of all four lakes. Lindsåsasjön is regulated. For Mycklaflon, water level changes are a danger to the *Salvelinus umbla* spawning places.

Lindåsasjön: a lake with a very various vegetation. It has a monitoring of the water chemistry due to the national monitoring program (1/5) (inclusive metals, MÖV). Oxygen depletion appears in Lindåsasjön. Reserve freshwater resource for the municipality of Vetlanda.

Vrången: a quite untouched lake with no regulation, little discharge and little influence of drainage/ditching. Running monitoring program due to follow-up of liming activities (the lake is limed) (water chemistry 3/1, crayfishing 1/3, gillnet fishing 1/10).

Försjön: not regulated, quite untouched! No running monitoring.

Mycklaflon is classified as a lake of national interest for nature conservation, since it has a quite unaffected status and has Sweden's most southern population of *Salvelinus umbla*. This points out its clear and nutrient poor water (even though the nitrogen became more), which exists due to the large depth and cold bottom water with good oxygen conditions. This fish species needs further spawning places and enough food. It is threatened due to the water level lowering in 1884 and the implantation of whitefish (*Coregonus lavaretus*) and vendace (*Coregonus albula*) in the beginning of the 20th century. In 1982/84, even some other fish species as a food source for *Salvelinus umbla* by accident, possible concurrent to the young *Salvelinus umbla*, have been brought to Mycklaflon. There has also been introduction of *Salvelinus umbla* from lake Vättern to lake Mycklaflon (genetically aspects unknown) in 1937. Already in 1993, a protection plan and a control program (N, P) were recommended. Especially the *Salvelinus umbla* population/spawning should be monitored every autumn to see a possible change. Running monitoring exists due to 'samordnad recipientkontroll' (littoral fauna 1/3, metals in fish 1/3, sediment chemistry 1/6, water chemistry L2 2/1, phytoplankton 1/1, chlorophyll a 1/1) and 'länsinventering' (water chemistry 1/5). Threat: Fishing of red-listed species.

Natura 2000	*Cottus gobio*	Mycklaflon
Birds Directive	*Gavia arctica*	Försjön (Eksjö), Mycklaflon, Lindsåsasjön
	Pandion haliaetus	Försjön (Eksjö), Mycklaflon,
	Gavia stellata	Försjön (Eksjö)
Red-listed species	*Astacus astacus*	Vrången, Lindåsasjön, Försjön (Eksjö)
Further	*Nostoc zetterstedtii*	Lindåsasjön

Natural dystrophic lakes and ponds (3160)

Lake	***Area km²***
7 Bråtagölen and Kakelugnsgölen	0,01

The mire Kakelugnsmossen is a site with two natural dystrophic ponds (Kakelugnsgölen and Bråtagölen). Surrounding Natura 2000 habitats are *Transition mires and quaking bogs and Western taiga*. General forestry management and drainage/ditching threaten the ponds. There is no running monitoring of the ponds of that site.

Fennoscandian natural rivers (3210)

Site name	***Length of the Natura 2000 site***
A Emån (western part) (+ **B, C, D**)	35 km

For the habitat type of fennoscandian natural rivers, only one site, a part of the river Emån (only the watercourse itself), is proposed in the County of Jönköping. It is the lower part of Emån between Grumlan and the county border; the upper part of this site is 3260-habitat. But the monitoring will be discussed here for the whole Natura 2000 site. Emån is of national interest for nature conservation. Mainly because Emån is southeast Sweden's second largest watercourse with both slow and fast flowing parts and high biodiversity. Along the slow-flowing parts Emån is surrounded mainly by open land, as acres and pasture. At least 25 fish-species are found within the

river, further there are rare macrophytes and insects. Freshwater pearl mussel is known from two places in the main flow and from two tributaries. Otter has recently been observed at a few places. The valley is important for breeding and for resting birds. 'Habitat survey' of Emån and part of its tributaries has been done in 1998. Due to this exists a detailed description of the river and its catchment. The data, received by this, are a good basis for the monitoring (and management) of the Natura 2000 site. The catchment area is dominated by forest (50%) and agricultural used land (20%). If there are, as in Emån, many Natura 2000 sites in one river, it can be checked out what monitoring can be done only at a few places (if there is no reason for changes of that parameter between those places). Data from 'Habitat survey' show the migration barriers, as there are (badly placed) conduits, dams (sometimes not in use anymore), hydropower stations, and bridges. Buffer zones are very rare. Emån is regulated, due to (old) dams (partly not in use anymore) and hydropower stations.
Existing monitoring: Sampling points at seven points between Grumlan and the border of the County. Two more sampling points at inflows (Solgenån and Gnyltån, both also partly Natura 2000 sites).

Sampling points:	
Grumlans outflow	Phys-chem L1 6 el 12, phys./chem. L3 + Sn 6, benthic fauna 1/3, aquatic mosses 1
Downstream Vetlanda	Phys./chem. L1 12, phys./chem. L3 6, benthic fauna 1/3
Downstream Vetlanda ARV	Phys./chem. L1 + NH_4 and PO_4 6 or 12, benthic fauna 1/3, aquatic mosses 1
Downstream Sjunnen	Electro fishing 1, benthic fauna 1/3
Downstream Holsbybrunn	Phys./chem. L1 6, phys./chem. L3 + Sn 6, aquatic mosses 1
(Inflow Solgenån)	
Aspödammen	Metals in fish 1/3, PCB in fish 1/3, sediment 1/6
(Gnyltån inflow)	
Kungsbron/County border	Phys./chem. L1 12, phys./chem. L3 12 alt 6, aquatic mosses 1, benthic fauna 1

Species:

Natura 2000	*Margaritifera margaritifera*	(reintroduced)
Birds Directive	*Cygnus cygnus, Circus cyaenus, Circus aeruginosus, Gavia arctica, Alcedo atthis, Pandion haliaetus*	

Watercourses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation (3260)

Site name	***Length of the Natura 2000 area***
B Emån included in 'Emån (western part)' 3210	---------
C Illharjen included in 'Emån (western part)' 3210	---------
D Stora Illharjen included in 'Emån (western part)' 3210	---------
E Gnyltån	14 km
F Solgenån	0,8 km
G Allmänningsån	1,1 km
H Sällevadsån	16 km/6,8 km
J Fuseån	14 km

These eight sites are watercourses with floating-leaved vegetation. Illharjen and Stora Illharjen are sites around/parts of Emån, so they will be included in the monitoring of that river. The others are tributaries to Emån and need a specific monitoring. Gnyltån is protected as a whole, but only the watercourse itself, not the surrounding. For Emån, Fuseån and Solgenån (> 1 km) only a part of the watercourse itself is protected, whereas parts of the other watercourses go into greater (Natura 2000) conservation areas. These areas include predominately the habitat types *Western taiga*, *Fennoscandian deciduous swampwoods*, and *Transition mires and quaking bogs*. Further there can be found *Tilio-Acerion forests of slopes, screes and ravines*, *Fennoscandian hemiboreal natural old broad-leaved deciduous forests rich in epiphytes*, *Luzulu-Fagetum beech forest* and *Asperulo-Fagetum beech forests*. The watercourses are mainly surrounded by forests, but also at a bit lesser part by agricultural areas. The catchment areas are dominated by forest and agricultural used land. Further there are mires, lakes and builded sites. Due to the land-use, all rivers are somehow affected by the (anthropogenic caused) high loads of nutrients. Many watercourses are suffering from acidification, but some, as Solgenån not. For example Sällevadsån and Gnyltån are affected by liming activities (upstream). All watercourses are more or less influenced by regulation (hydropower stations). Other anthropogenic influences on the near surrounding or the watercourse itself are grounded for example in golf courses, irrigation, dumps, and industry. All theses watercourses have already been monitored due to 'Habitat survey watercourse'. The data, gotten by this, will be a good basis for the monitoring (and management) of the Natura 2000 sites. Data from 'Habitat survey' show that today all of the watercourses in concern are influenced by migration barriers, as there are (badly placed) conduits, dams (sometimes not in use anymore), hydropower stations, bridges (otter for example Almänningsån

RV 33). All the rivers are somehow fragmented. Influences on the near surroundings: golf courses, industry, dumps, fish farming (for example Almänningsån), shooting-sites (for example Almänningsån), clear cutting (for example Almänningsån), storm water, freetime/touristic activities (highly frequented hiking paths). Repeated cleaning of the sediment and vegetation: Exists (Sällevadsån). Whereas *Pacifastacus leniusculus* in all five watercourses, rainbow trout (for example Almänningsån), pikeperch, *Elodea canadensis* (for example Almänningsån)

Illharjen/Stora Illharjen: sites of/around the Natura 2000 site 'Emån'. No specific monitoring necessary (for the macrophyte inventory: maybe some fix points at this site)

Gnyltån: The catchment area is 74 km^2, whereof 89% are forest (mainly spruce). In 1998 4% of the shore length was clear-cut. A buffer zone (<3m) was missing at 36% of the shore length. Earlier, Fagerhultasjön has been limed. Running monitoring: Fagerhultasjön (phys./chem. L2 3, gillnet fishing 1/10 next 2003), Gnyltån (phys./chem. L1 6, vattenkemi3 6/1, electro fishing 1/1 + 1/3 + 1/3, benthic fauna 1/3), Lillån inflow (phys./chem. L1 6). There are no urban areas, existing monitoring is paid by Emåns vattenförbund and the county's follow-up of liming activities.

Solgenån: < 1 km between Klintedammen and Brunnshultadammen (both nutrient rich). Downstream can the watercourse have no water for some time. Running monitoring: inflow Emån (phys./chem. L1 12, phys./chem. L3 6, aquatic mosses 1, benthic fauna 1/3)

Almänningsån: No running monitoring. In Långaäsasjön (Almänningsån runs through it) the sediment is investigated (1/6) due to the effect of the city dump of the town Eksjö and the military area of Eksjö garrison. Next water chemistry measuring point is downstream of Solgenån by Markestad (phys./chem. L1 12/1, phys./chem. L2 6/1 limited).

Sällevadsån: between the lakes Flen and Vensjön. This nutrient poor, 16 km long river has a 102 km^2 large catchment area, whereof 88% are forest, sparsely populated. It has a good buffer capacity. In 1998 at 9 % of the riparian zone length appeared clear-cutting. A buffer zone (<3m) was missing at 10 % of the riparian zone length. Running monitoring: Flen (Phys./chem. L2 2, plankton 1, chl a 1/3, benthic fauna 1/3), Sällevadsån 2 Km SV Boda (electro fishing 1), Åbro (phys./chem. 6 timeseries, benthic fauna 1/3 1999, electro fishing 1/3 1999) (how regular?!). The running monitoring pays Emån's vattenförbund. Sällevadsan is strongly affected by mercury (downstream of the lake Flen) and cadmium (measured in the aquatic mosses).

Fuseån: Running monitoring: Upstream the area at lake 'Nömmen' (phys./chem. L2 2, plankton 1, Chl a 1, Benthic fauna 1/3, sediment 1/6), downstream Ryningsholm (phys./chem. L1 6). (further downstream Markestad, same station for Almänningsån).

Natura 2000	*Lutra lutra* *Margaritifera margaritifera*	Sällevadsån, Allmänningsån, Solgenån, Fuseån Sällevadsån, Gnyltån

a2) Emån north of the mainflow

Oligotrophic to mesotrophic standing waters with vegetation of the littorelletea uniflorae and/or of the Isoeto-Nanojuncetea (3130)

Lake	*Area km^2*	*Depth (max/average)*	*Retention time a*	*Volume 1.000.000 m^3*	*Catchment km^2*	*Shore-length km*
8 Fjärasjö	0,35	13/4,3	2,86	1,49	2,4	3,3

Fjärasjö is a slightly dystrophic, oligo- to mesotrophic lake with *Littorelletea uniflorae* or *Isoeto-Nanojuncetea* vegetation. It has two tributaries and is surrounded by forest (and bogs). Fjärasjö is a national reference lake (littoral fauna 1/1, profundal fauna 1/1, water chemistry F9 4/1, phytoplankton 1/1, gillnet fishing 1/3). Further crayfishing 1/3 is done due to the follow-up of liming activities. The lake lies not in an easily acidified area.

Birds Directive: Red-listed species:	*Gavia arctica* *Astacus astacus*

Migration barrier occur with the outflow/downstream at Fjärasjö. *Pacifastacus leniusculus*has been introduced.

Watercourses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation (3260)

Site name	*Length of watercourse/of Natura 2000 site*
I Silverån	25,4 km/15 km

In Silverån only a part of the watercourse itself is protected. The catchment area is dominated by forest and agricultural used land. Further there are mires, lakes and builded sites. Due to the land-use, the high loads of nutrients affect the river. The watercourse is already monitored with the 'Habitat survey'. The river has a catchment area of 109 km^2, of which 89% is forest. In 1998 6% of the riparian zone length was affected by clear cutting and a buffer zone (<3m) was missing at 53% of the riparian zone length. There are no large urban areas close to Silverån. Running monitoring is paid by Emån's vattenförbund. Existing monitoring at Hulta såg (phys./chem. L1 12/1, phys./chem. L3 6, Benthic fauna 1). *Pacifastacus leniusculus* occurs.

a3) Emån south of the main flow

Oligotrophic to mesotrophic standing waters with vegetation of the littorelletea uniflorae and/or of the Isoeto-Nanojuncetea (3130)

Lake	*Area km²*	*Depth (max/average)*	*Retention time a*	*Volume 1.000.000 m³*	*Catchment km²*	*Shore-length km*
9 Färgsjö	0,15	14/4,8	1,184	0,72	17,7	Ca 1-2 km

Färgsjö lies in the protected area 'Färgsjömon' and only a small part of the lake goes into the Natura 2000 habitat. The surrounding habitat is *Western taiga*. Besides of the part, where the Natura 2000 forest borders to the lake, the lake is surrounded by forests (clear cutting occurs). Otherwise there are no buildings, roads or agriculture close to the lake. There exists no monitoring program for this lake.

Natural dystrophic lakes and ponds (3160)

Lake	*Area km²*
10 Part of Borgaregölen (Stora och Lilla Fly) (+ other small ponds)	0,02
11 Part of Hultagölen (Hökatorp)	0,021
12 Several ponds, as e.g. Tranhalsagölen, part of Trelleborgagölen (Svarta håls vildmark)	0,01 + 0,02

These natural dystrophic ponds are all within larger protection areas. Surrounding habitats are *Transition mires and quaking bogs Western taiga* and *Active raised bogs*. In Hökatorp and Svarta håls vildmark, several ponds are found. Sometimes only parts of the ponds are protected. All places lie very much up in the water system and only Svarta håls vildmark has a surface water outflow (no inflow at any pond). That these lakes and ponds are (partly) surrounded by protected areas inhibits mainly two points: First that there can be a special strong pressure of leisure and free time activities (hiking paths: Stora och Lilla Fly). On the other hand, there are seldom buildings at the shorelines and no agriculture and forestry, so there are little or none diffuse and point sources for environmentally threatening substances (nutrients, pesticides, metals). Further it means also that the other Natura 2000 habitats have a monitoring program too. Threat of general forestry management and drainage/ditching (Hökatorp, Svarta håls vildmark). There exist not monitoring for theses areas.

Watercourses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation (3260)

Site name	*Length of the watercourse/of the Natura 2000 site*
M Helvetes Håla/Hålebäcken	380m

A part of Hålebäcken goes into the Natura 2000 site 'Helvetets Håla'. The surrounding habitat type is *Western taiga*. There does not exist very much data on this watercourse. Next watercourse classified by Habitat survey is Farstorpaån. This investigation should be done for (part of) Hålebäcken as well. The catchment area is dominated by forest and agricultural used land. influenced by regulation (hydropower stations). The watercourse is mainly surrounded by forests, but also at a bit lesser part by agricultural areas. Existing monitoring: water chemistry 3 12 (follow-up of liming activities 1999), benthic fauna 1/3.

b) Lagan

Oligotrophic waters containing very few minerals of sandy plains (Littorelletalia uniflorae) (3110)

Lake	*Area*	*Depth (max/med)*	*Retention time*	*Volume*	*Catchment*	*Shore length*
13 Hindsen	12,69	17,0/5,7	5,15	75,20	44,1	52,7

Hindsen is surrounded by both forest- and agricultural used land and only protected itself, without surrounding habitats. The lake lies in an easily acidified area and influences on the near surroundings come from swimming places/beaches (threat to the vegetation), summer cottages, and a golf course. Migration barriers occur downstream. *Pacifastacus leniusculus* (Signal crayfish) occurs. The lake is limed and has a running monitoring program due to the follow-up of liming effects (water chemistry 2/1 north, Nostoc z. 1/5 planned, water chemistry 3/1 south, gillnet fishing 1/5 (national object). 'samordnad recipientkontrol' (Littoral fauna 1/3, sediment chemistry 1/6, water chemistry L2 1/1, phytoplankton 1/1. Fin. by SRK) and national inventory (water chemistry lake 1/5).

Birds Directive	*Pandion haliaetus, Gavia arctica, Sterna hirundo*
further	*Nostoc zetterstedtii*

Oligotrophic to mesotrophic standing waters with vegetation of the littorelletea uniflorae and/or of the Isoeto-Nanojuncetea (3130)

Lake	*Area*	*Depth (max/med)*	*Retention time*	*Volume*	*Catchment*	*Shore length*
14 Övingen	2,46	27,5/8,2	5,51	22,8	14,5	15,7

Mainly forests surround Övingen. Special threats are the general forestry management, drainage/ditching, eutrophication, and discharge of fish growing. Migration barrier occur with the outflow/downstream. Signal crayfish occurs. Övingen is not limed but monitored due to the follow-up of liming activities (gillnet fishing 1/10).

Natural eutrophic lakes with Magnopotamion or Hydrocharition-type vegetation (3150)

Lake	other habitat types	Area (km^2)	Shore length
15 Draven		1,8	Ca 9 km

This lake is the only represent for natural eutrophic lakes in the County of Jönköping. Surrounding Natura 2000 habitat types are alkaline fens. Draven is surrounded by grazed meadows and acres. The lake is one of Smålands most important and most species rich site for birds. The catchment area includes mainly forests and mires, and only little agriculture. Existing threats are hiking and other leisure activities. Lowering of the water level was carried out several times since the 1800 century. The following revegetation was a threat to the bird-life. Draven is a nature reserve and restored since 1993 (higher water level). Migration barriers occur upstream. There is a running monitoring due to 'samordnad recipientkontrol' (water chemistry L1 12/1)

Birds Directive	*Grus grus, Cygnus cygnus*
Red-listed species	*Astacus astacus*

16 ***Store Mosse National park***

Lake	***Area km^2***	***Depth (max/med)***	***Volume 1.000.000 m^3***	***Catchment***	***Shore length km***
Kävsjön	1,397	1,2/1			20,9
Svartgölen	0,07				
Svartegöl	0,03				
Häradsögölarna (6?)	0,11				
Häradsösjön	0.04				
Horssjön					
Kalvasjön	0,28	4,5/1,5	0,42	6,8	2,4
Vitgölen	0,02				

Store Mosse is southern Sweden's largest interconnected bog area. Due to its value for migratory birds, the area is included in the Ramsar convention (1974) and the Birds Directive and since 1982 it has the status of a national park (7 682 ha, whereof 1 422 ha land). The area has the status of national interest for outdoor recreation. There are several ponds and lakes in the area, whereof three lakes have been either completely or partially drained. Only Kävsjön and Kalvasjön have open water areas during summer, the others are more or less revegetated (due to the water level lowering). The national park lies mainly in the catchment area of Storån; Horssjön and its surrounding water through Lillån to Lagans water system.

The largest parts of the bogs and forests are left to develop freely. Mowing is also to be done around parts of Kävsjön, as well as clearing up of all wood. The revegetation shall be prohibited. Measures are done since the middle of the 1980ies. Further, investigations shall be carried out to define the possibility for and the consequences of a restoration (2003-2005) of Kävsjön. A hydrological investigation of the whole area is planned to be done, to find out how the restoration can look like and what consequences there are, if the ditches in the area are not cleaned anymore.

In the Natura 2000 site are further, additionally to the natural dystrophic lakes and ponds, several terrestrial Natura 2000 habitat types found.

Most of the studies for the lakes, the vegetation and the birds of the national park have been done around 1970. Effects of: railway and road, earlier peat digging, (total and part) drainage of three lakes, outdoor recreation (parking places, hiking paths ca 40 km, bird tower, cabins). Every year ca 80 000 visitors. revegetation due to lower water level. The last satellite analysis has been done in 1999.

Existing monitoring only in Kalvasjön (riksinventering): water chemistry (1/5) and littoral fauna (1/5)

Kävsjön is a relatively eutrophic peat land lake, its shores are flat and organogenic. Large dense *Schoenoplectus lacustris*-reeds grow in the southwest part of the lake, additionally, sparse *Equisetum fluviatile* vegetation is found in large parts. On the southern edge of the lake lies a large quagmire. Along the southern and eastern edges of this, there are found a number of ponds ('gölar') with open water surfaces and that are in direct connection with the lake (**Svartgölen**, **Vitgölen**, **Häradsögölarna**). The surrounding is totally dominated by bogs. The catchment is 36,5 km^2 large and consists mainly of bogs with segments of forest- and agricultural land. Migration barriers are found up-and downstream in Storån. Kävsjön can be seen as fairly unaffected, lacking water level regulations, showing only low acidification affection, a total lack of buildings along the shores, and insignificant discharge. The lake was once much larger. In 1840, the water level was lowered by more than one metre. The lake bottom, which was drained, became meadow or hay-land and a very good environment for birds. When the grazing and haymaking ended in the beginning of the 2000th century, the land became overgrown. The new conditions were negative especially for wading birds and migrating ducks. Grazing and mowing are now being resumed in an attempt to restore the lake to a favourable habitat for birds. Kävsjön has a very high biological function and contains high rarity values. It has the national status as a bird lake with for example breeding *Anas querquedula, Circus aeruginosus, Lymnocryptes minimus, Anas penelope, Cygnus cygnus, Anser anser, Anas acuta, Anas clypeata*, *Tringa glareola*. Due to its importance for birds, there are entrance restrictions between March and September around the lake (apart from hiking trails). Kävsjön is also very important as a resting place. Even a small population of *Astacus astacus* is found here. Other birds, bound to water and nesting in the park are *Grus grus, Pluvialis apricaria, Gavia arctica.*

Kalvasjön is a heavily humic oligotrophic lake, surrounded by almost only bogs. Only in the northeastern part exists forest. The catchment consists mainly of forest and bogs with little agriculture. Migration barriers are found up- and downstream in Storån. The lake is strongly influenced by acidification. The biodiversity is not very rich.

Horssjön and Häradsösjön have also been drained to produce hay meadows. The old lakebeds are today covered with fen and quagmire.

Birds Directive	*Circus aeruginosus, Cygnus cygnus, Tringa glareola, Grus grus, Pluvialis apricaria, Gavia arctica*	Breeding

Natural dystrophic lakes and ponds (3160)

Lake	*Area*	*Depth (max/med)*	*Retention time*	*Volume*	*Catchment*	*Shore length*
17 Mossjön	0,47	5,2/1,8	0,88	0,9	3,8	4,6

Lake Mossjön, which is only protected itself, is natural acid and shows an ecosystem fitted to that special environment. There live for example some species of benthic red algae that avoid limestone. Its bottom is covered by white-mosses. Mires and forest dominate the surrounding. The catchment is dominated by mires (56%) and forest (30%). Downstream exist several migration barriers. Strong blooming of *Gonyostemum semen* appears in some years. Threat of drainage/ditching. Influence on the near surroundings: Forest management, free time activities. White-mosses cover large parts of the lake. Since 1983, Mossjön is a national reference lake for the liming organisation and may not be limed or influenced in any way. Water quality (4/1), littoral fauna 1/1, profundal fauna 1/1, phytoplankton 1/1, gillnet fishing 1/3.

Watercourses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation (3260)

Site name	*Length of the Natura 2000 site*
N Årån	8,8 km
O Vikskvarn: Storkvarnaån	2 km

These two sites go into greater (Natura 2000) conservation areas. The catchment areas are dominated by forest and agricultural used land. Further there are mires, lakes and builded sites. Storkvarnaån is affected by liming activities (upstream). Storkvarnaån is already monitored by 'Habitat survey'.

Natura 2000	*Lutra lutra*	Årån
Red-listed species	*Astacus astacus*	Årån

c) Svartån's Catchment

Oligotrophic to mesotrophic standing waters with vegetation of the littorelletea uniflorae and/or of the Isoeto-Nanojuncetea (3130)

Lake	***Area m^2***	***Depth (max/med) m***	***Retention time a***	***Volume 1.000.000 m^3***	***Catchment km^2***	***Strand length km***
18 Drängagråten	>1000	-	-	-	-	-
24 Strånnesjön	0,12	9/5,3	-	0,63	-	-
21 Illern	0,44	7/2,9	2,76	1,3	2,5	4,4
20 Bordsjön	0,5	9,5	-	-	-	3,6
22 Sötåsasjön	1,21	15,6/4,2	2,74	5,26	7,6	10,1
23 Försjön (Aneby)	1,63	21/5,7	4,2	9,35	10,45	11,1
19 Assjön	4,89	26/10,9	-	53,3	21,9	15,3

Lake Illern, Försjön (Aneby) and Drängagråten are surrounded only by forest (and bogs), whereas Assjön, Sötåsasjön and Bordsjön have both forest and agriculture in the surrounding. Strånnesjön has no in- and outflow. General forestry management threatens lakes surrounded be forest, as Drängagråten. Bordsjön and Assjön are influenced by drainage/ditching and Illern, Bordsjön, Sötåsasjön and Assjön are threatened by diffuse discharge of the agriculture (nutrients and pesticides). Sötåsasjön has been suffering under oxygen depletion. The lakes are not surrounded by other protected (and monitored) areas. No regulation of Illern, Försjön/Aneby. Migration barriers occur with the outflow/downstream at Bordsjön, Assjön (outflow), Sötåsasjön, Försjön (Aneby). *Pacifastacus leniusculus* has been introduced in Illern (some *Astacus astacus* left) and Försjön/Aneby.

Drängagråten: Drängagråten is a small pond ('göl') in the forest and has no running monitoring; a salamander-inventory has been done in 1998. Threats for *Triturus cristatus* are mainly introduction of fish and crayfish, acidification, nutrients and pesticides and ditch/drainage. For the terrestrial environment this species needs wet forest and overwintering places (dead trees or stone places). Around the pond open land (sunny and warm), wet forest in the surrounding.
Strånnesjön: Without in- and outflow and without running monitoring program.
Illern: no running monitoring
Bordsjön: no running monitoring
Sötåsasjön: running monitoring due to the national inventory program (littoral fauna 1/5, water chemistry 1/5).
Försjön (Aneby): has a running monitoring due to its state as a reference lake (littoral fauna 1/1, profundal fauna 1/1, water chemistry lakes 4/1, phytoplankton 1/1, gill net fishing 1/3).
Assjön: a lake with a very good water quality; running monitoring due to the national inventory program (water chemistry 1/5)

Natura 2000	*Triturus cristatus/vulgaris*	Drängagråten
	Cottus gobio	Mycklaflon
Birds Directive	*Gavia arctica*	Bordsjön, Assjön, Sötåsasjön
	Sterna hirundo	Assjön
	Pandion haliaetus	Assjön, Sötåsasjön
Red-listed species	*Astacus astacus*	Strånnesjön, Illern, Bordsjön and Sötåsasjön

d) Tidan's catchment

Natural dystrophic lakes and ponds (3160)

Lake	*Other habitat types*
25 Bottnaryds urskog (pond)	7140, 9010, 9100

Surrounding habitats are *Transition mires and quaking bogs* and *Western taiga*. There is no information on the pond and there exist no monitoring.

e) Vättern's 'catchment'/Motala stream

Oligotrophic waters containing very few minerals of sandy plains (Littorelletalia uniflorae) (3110)

Lake	*Area*	*Depth (max/med)*	*Retention time*	*Volume*	*Catchment*
26 Kansjön	0,79	14,5/4,7	1,68	3,72	6,7

This lake is surrounded by both forest- and agricultural used land and only protected itself, without the surrounding habitats. The lake has high P-values in the surface water, further some changes in the fish community and it is strongly influenced by cottages. The development of the reed-vegetation (*Phragmites australis*) should be carefully observed, since it is quite common already, and a sure sign for eutrophication. Migration barriers occur downstream.

Red-listed	*Astacus astacus*
Further	*Nostoc zetterstedtii*

Oligotrophic to mesotrophic standing waters with vegetation of the littorelletea uniflorae and/or of the Isoeto-Nanojuncetea (3130)

Lake	*Area km^2*	*Depth (max/med)*	*Retention time a*	*Volume*	*Catchment*	*Strand length km*
29 Strandgölen	0,01	-	-	-	-	-
28 Rödsjön	0,07	4,6	-	-	-	-
30 Ören (Röttleån)	9,19	35,8/12,7	13	117	84,2	33,6
(**27** Vättern south: see spec. part about Vättern)						

Lake Ören is surrounded by both forest and agricultural used land and is threatened by eutrophication, fishing of red-listed species (one of few *Salvelinus alpinus salvelinus* waters in the southern most part of Sweden, *Coregonus trybomi*), and swimming places. Rödsjön and Strandsjön lie in the nature reserve 'Hökensås' and are surrounded by coniferous forest (forestry occurs). The strands are mostly minerogenic (stony, sandy). Both lakes are used for fishing activities, including problems of rubbish, destroyed strand and aquatic vegetation, noises, cars, etc. Rödsjön and Strandgölen, but not Ören, lay in an area that is threatened by acidification. Regulation and migration barrier occur with the outflow/downstream at Ören.
There is no running monitoring for Rödsjön and Strandgölen.
Ören has a running monitoring due to 'Samordnad Recipientkontroll' (water chemistry L2 2/1, phytoplankton 1/1, chlorophyll a 3/3) (financed by SRK).

Natura 2000	*Lutra lutra, Cottus gobio*	Ören
Birds Directive	*Gavia arctica, Pandion haliaetus*	Ören

Hard oligo-mesotrophic waters with benthic vegetation of Chara ssp. (3140)

Lake	*other habitat types*	*Area (km^2)*	*depth (max/med)*	*retention time*	*volume*	*catch ment*
27 Southern part of Lake Vättern	3130	9900	128/40	58	74000	6359

This unique lake represents the only Natura 2000 example for a hard oligo-mesotrophic habitat with benthic vegetation of *Chara* in the County of Jönköping. The lake has further oligo-mesotrophic Natura 2000 habitats. Only the lake itself is protected by Natura 2000. Vättern is the second biggest lake in Sweden. It is a stable ecosystem with very good water quality and cold water. The lake has a good buffering capacity against acidification, due to the large surface, a high pH, and high alkalinity. Vättern has many inflowing watercourses, which are relatively small. Due to the large lake surface compared to the catchment area, the precipitation directly on the lake is of great importance. Forests and lakes dominate the catchment area. Some cities (Jönköping and Huskvarna as the biggest in the southern part) and villages border directly to the lake.
The lake has a lot of national red-listed fish- and invertebrate species. Additionally, unique fauna with *Salvelinus alpinus salvelinus* and some glacial relicts of invertebrates. At least 28 fish species. National interest for nature protection. Conflict of interests: Strong importance as drinking water resource (for 300 000 people), professional and free time fishing, leisure activities, recipient for factories and communes. Fishery: 25 fulltime fishers (1997: 90 ton). Threats are for example fishing of red-listed species. Vättern's value for free time activities, tourism, and recreation is named in the Environmental code. Boats, small boat harbours, ferry, swimming, military activities: wastewater treatment plants: several, direct and indirect, daywater: direct and indirect from all cities. The water level is regulated by the power station at the outflow by the city Motala. High water levels (as in 1999) cause flooding and high erosion. Influence of leisure activities, Swimming places/beaches, industries, cities. Migration barriers occur, downstream. Monitoring of the migration ways upstream, should be open for the fishes of Vättern (spawning places)
For Vättern exists already a good monitoring program (Vätternvårdsförbund 2001: 'Program för samordnad miljöövervakning i Vättern och dess tillflöden 2001-2006'). Two new moments are suggested to go into the monitoring in the long run: 'Macrophytes' (including periphyton) and 'Environmental threatening substances in fish'. The yearly reporting will be fitted to the needs of the WFD and a larger evaluation of the monitoring will be done every sixth year.
Vättern's stabile and well mixed water column together with its long retention time causes that the variations of the water chemistry are small both in time and space. Regular measures since 1966/1978. The water quality is measured yearly in April, Mai, July and August at two places in the lake plus at all larger inflowing watercourses. Vättern's catchment is already monitored due to the program 'water chemistry in the tributaries'. Phytoplankton is measured at the same two stations as for the water quality, yearly in the middle of April, Mai, June and August, since 1966 and 1978.

Monitoring type (selection)	***Status (2001-02)***
Water chemistry in lakes	Due to existing programs
Phytoplankton	Due to existing programs
Zooplankton	Due to existing programs
Bottom fauna	Due to existing programs
Water chemistry in the outflow	Due to existing programs
Water chemistry in the tributaries	Due to existing programs
Monitoring of pelagic fish (Echo counting)	Due to existing programs, moreover included: catch statistics
Toxic substances in fish	New suggestion, no financing yet, program exists
Vegetation	Macrophytes, periphyton: New suggestion
Precipitation chemistry	Due to existing programs
Fish investigations	Three different moments suggested
Screening of environmental threatening substances	Two different moments suggested
Paleoreconstruction	In Vättern 2001
Primary production	Done in Vättern 2000, not to be in the long-run
Investigation of threatened and/or rare species	Chara-investigations 2001
Investigations of non-native and/or genmodified organisms	
Habitat survey of the tributaries	2001-2002
Monitoring of glacialrelicts	
Investigation about lake morphology, water level, erosion, ice-occurence	
Breeding birds on (rocky) islets and islands	Program maybe under 2001 (?)
Sediment chemistry	Study done in 1972/73

Species

Natura 2000	*Cobitis taenia, Cottus gobio*

Natural dystrophic lakes and ponds (3160)

Lake	*Area*	*Depth (max/med)*	*Volume*
31 Dumme mosse (Stora Tjärnen) V/(Domneån)/Tabergsån			
32 Bottenlösen	0.01		
33 Gållsjön	0,01	1/0,5	0,01
34 Bare mosse () V/Motalaström (Tidan/Götaälv)			

All these ponds and lakes are part of larger protection areas, including other Natura 2000 habitats as *Transition mires and quaking bogs*, and *Western taiga*. At many sites several ponds are found. There can be a strong pressure of leisure and leisure activities (hiking paths in Dumme Mosse). On the other hand, the fact that some habitats are surrounded by other Natura 2000 habitat types and thereby protected (as well as other sites that go into an older protection type) means that there are seldom buildings at the strandlines and no agriculture and forestry, so there are little or none diffuse and point sources for environmentally threatening substances (nutrients, pesticides, metals). Peat mining in Bare Mosse has strongly affected the mire. Bottenlösen and Gållsjön lie in easily acidified areas. Threat of general forestry management (Dumme Mosse) and drainage/ditching (Bare Mosse). All ponds of these sites have no running monitoring.

Watercourses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation (3260)

S Röttleån (Vestanå 2 ha)
P Domneån (1 ha)
Q Gagnån (3,5 ha)
R Holmån (0,5 ha)

Of all four watercourses only parts are Natura 2000 sites. For Holmån only the part in the nature reserve 'Hökensås' is protected (no other Natura 2000 habitats), Gagnån is protected from Stenmossen to Fagerhult. Röttleån and Domneån are both protected where they flow intom Vättern. There, they are surrounded by other Natura 2000 habitats. Röttleån: *Western taiga*, *Tilio-Acerion forests of slopes, screes and ravines*, *Fennoscandian hemiboreal natural old broad-leaved deciduous forests rich in epiphytes*, *Luzulu-Fagetum beech forest,* and *Asperulo-Fagetum beech forests*. Domneån: *Fennoscandian deciduous swampwoods*, and *Transition mires and quaking bogs*.

The catchment areas are dominated by forest and agricultural used land. Further there are mires, lakes and urban areas. Due to the land-use, all rivers are somehow affected by high loads of nutrients. Many watercourses are suffering from acidification, but some, as Röttleån, and Domneån not. Almost all of these watercourses are more or less influenced by regulation (hydropower stations). Other anthropogenic influences on the near surrounding or the watercourse itself are grounded for example in golf courses (pesticides, for example Röttleån), irrigation, dumps, and industry (eg. Domneån). Water take out during low flow periods mainly for agriculture (Domneån), but also for fish-farming, golf-courses (Röttleån). All of the watercourses in concern are already monitored with the habitat survey. Apart from Holmån, all watercourses have running monitoring programs.

f) Ätran's catchment

Oligo- to mesotrophic lakes with Littorelletea uniflorae or Isoeto Nanojuncetea vegetation (3130)

35 Fegen

Forests mainly surround the Lake Fegen. Threats are leisure activities, swimming places/beaches, and fishing activities. Liming affects Fegen (before acidification problem). Existing monitoring: water quality 1/1, phytoplankton 1/3, littoral fauna 1/3.

Birds Directive	*Gavia arctica, Pandion haliaetus, Gavia stellata*
Red-listed species	*Coregonus trybomi, Astacus astacus*

g) Mörrumsån's catchment

Natural dystrophic lakes and ponds (3160)

Lake	*Other habitat types*	*Lake Area Km^2*
36 Skoggölen/Kråketorpsskogen	7140, 9010, 9100	0,02

Skoggölen is a natural dystrophic pond within a larger protection area called 'Kråketorpsskogen'. Surrounding habitats are *Transition mires and quaking bogs*. There are very few data on this small pond, it is just mentioned in the lake register. General forestry management and drainage/ditching threaten the lake. There is no running monitoring of Skoggölen today.