Revised Terms of Reference [28/11/2000]

Heavily Modified Waters in Europe
Case Study on Lake Loosdrecht

C.M. Lorenz of W+B

In association with

DWR

RIVM

W+B Deventer
Post box 233 7400 AE Deventer
tel. 0570-697272
Fax 0570-697344
Email: c.lorenz@witbo.nl

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PART I

1 Preface [to be drafted by project managers] (1 page)

[insert the standard preface - drafted by the project managers - briefly explaining the European project on heavily modified water bodies as the context for the individual case study. This should explain the context to readers of the case study, who may not be familiar with the European project.]

2 Summary Table (2 pages)

[insert the summary table on the case study already provided; "Annex IV" of the minutes of the kick-off meeting of the European project on heavily modified water bodies.]

	Item	Unit	Information
1.	Country	text	Netherlands
2.	Name of the case study (name of water body)	text	Lake Loosdrecht
3.	Steering Committee member(s) responsible for the case study	text	RIVM / RIZA
4.	Institution funding the case study	text	RIVM
5.	Institution carrying out the case study	text	Witteveen+Bos
6.	Start of the work on the case study	Date	1 October 2001
7.	Description of pressures & impacts expected by	Date	December 2001
8.	Estimated date for final results	Date	December 2001
9.	Type of Water (river, lake, AWB, freshwater)	text	Freshwater Lake
10.	Catchment area	km^2	44 km^2
11.	Length/Size	km/ km^2	Size is 10 km^2 and mean depth is 1,85m
12.	Mean discharge/volume	m^3/s or m^3	The total water volume is $20*10^6$ m^3 . The hydraulic retention time is ± 5-6 months
13.	Population in catchment	number	Main municipality in catchment is Loosdrecht with 8.808 inhabitants. Next to the inhabitants, the area accommodates ± 20.000 holiday-makers/year (remaining one week or longer) and ± 100.000 day trippers.
14.	Population density	Inh./km^2	8.808 / 44 = 200 Inh/ km^2
15.	Modifications: Physical Pressures / Agricultural influences	text	– Hydrological and water quality changes in the lake caused by a drastic change of the hydrology of the catchment due to the reclamation of low-lying polders and groundwater extraction in infiltration areas – Fixed water level for protection of the peatbanks – Construction of unnatural embankments for the protection of the peat banks and to optimise recreation – Creation of artificial islands in the lake – Diffuse and point source pollution from the surrounding households and agriculture in the catchment
16.	Impacts?	text	– Eutrophication of the lake due to in hydrological and water quality changes in the lake due to a drastic change of the hydrology of the catchment. Eutrophication has led to a layer of easily resuspendable silt. – Fixed water level – Construction of unnatural embankments along almost the whole lake – Creation of artificial islands in the lake

	Item	Unit	Information
17.	Problems?	text	Eutrophication has led to a turbid, eutrophic lake dominated by cyanobacteria and detrital matter.
18.	Environmental Pressures?	text	– Drinking water extraction – Recreation – Agriculture – Habitation – Water management and flood protection
19.	What actions/alterations are planned?	text	Measure to decrease the turbidity caused by the resuspended silt: Creation of a silt catch by digging of ±15 m deep in 10% surface of the lake.
20.	Additional Information	text	The main cause for the present eutrophication problems are human alterations in and outside the catchment of the lake. The reclamation of low-lying polders and the extraction of drinking water has changed the groundwater hydrology and the seepage and infiltration pattern. Nutrient rich surface water had been let in to the lake to compensate for the reduction in seepage water, leading to eutrophication. The eutrophication has been tackled by a number of measures, namely: 1. Construction of a sewer system surrounding the Loosdrecht lakes 2. Changing the source of the inletwater from river Vecht to Amsterdam Rhine canal 3. Dephosphorizing the inlet water (most important for reduction of nutrient loading) 4. Reduction of diffuse pollution from recreation yachts
21.	What information / data is available?	text	Data on hydromorphology, water quality, algal concentrations, macrophytes and fish.
22.	What type of sub-group would you find helpful?	text	Multifunctional
23.	Additional Comments	text	The nutrient and algal concentrations are relatively low, but the water is still turbid due to the detrital matter. There is no experience with removing this (organic and anorganic) silt particles. An experimental dredging is planned for 2004 (see above).

3 Introduction (2 pages)

These Terms of Reference should guide the production of the case studies reports to be written in the framework of the European project on heavily modified water bodies. They are provided as a standard report format **which can simply be overwritten**. Please do not alter the formatting of paragraphs, headings etc. For tables and boxes within this case study, please make use of the following models:

Table 1 [model heading for a table]

Box 1 [model heading for a box or map]

You received two files of Terms of Reference for your case study. In general, you should only use file ‚HMWB TOR' consisting of Part I, II and III for producing your case study. Part I includes chapters 1-4 which give an introduction to the case study. In chapter 4, you should identify different water bodies within your case study area.

In Part II, the physical alterations, the ecological status, the identification and designation as heavily modified and the definition of maximum and good ecological potential (see chapters 5-9) should be described for the water bodies in the case study area. In general, it is expected that the different water bodies in your case study would be affected by similar pressures and physical alterations.

Part III is dedicated to highlight main findings during the identification and designation process and the lessons learned in the case study. Please try not to exceed a total of 50 pages (excluding maps and annexes). A number of pages is also indicated for each section next to the first level heading to guide the authors. They do not intend to be prescriptive.

In case your case study consists of water bodies affected by substantially different pressures and physical alterations, please try to group them (to a limited number of groups) by similar pressures and physical alterations (in chapter 4). If the impacts of these pressures are distinct it would be useful to report your Part II results separately. Use the separate file ‚HMWB extra Part II TOR' and complete it separately for each impact group. In total, please do not exceed a length of 80 pages (excluding maps and annexes), including all groups of water bodies.

3.1 Choice of case study

This case study is about a Dutch shallow freshwater lake; Lake Loosdrecht. There are two Dutch lakes in the HMW case study project; Lake Loosdrecht and the Veluwe randmeren. Both lakes have been influenced drastically by hydromorphological changes. Both lakes have different water authorities: The Veluwerandmeren are managed by Rijkswaterstaat, acting on a national scale. Lake Loosdrecht is managed by the Water boards, acting on a regional scale.

Lake Loosdrecht has been selected as a case, because its morphology is typical for Dutch shallow lakes. The history of Lake Loosdrecht is relatively complex. Industrial peatmining created the preconditions for the creation of the lake. Natural processes have formed the present lakes, as subsequent wind and wave action eroded the rest of the peatbanks and a system of shallow, interconnected lakes developed. To protect the remaining peatbanks from crumbling away unnatural embankments have been constructed. The present lake has been impacted by numerous human uses and even impacts outside the catchment have led to drastic hydromorphological impacts in the lake.

Next the characteristics of the lake, Loosdrecht has been selected as a case, because its functioning has been studied extensively. There are many data and studies available for this case study. Moreover, it is an eutrophicated lake on which a number of restoration measures have been applied. Despite this measures, the lake still hasn't switched to a clear equilibrium (see for more information the theory on eutrophication of shallow lakes).

3.2 General Remarks

[Explain the location and nature of the water bodies within the case study area (map). Explain the place of the case study in the sub-group structure adopted by the European project on heavily modified water bodies.]

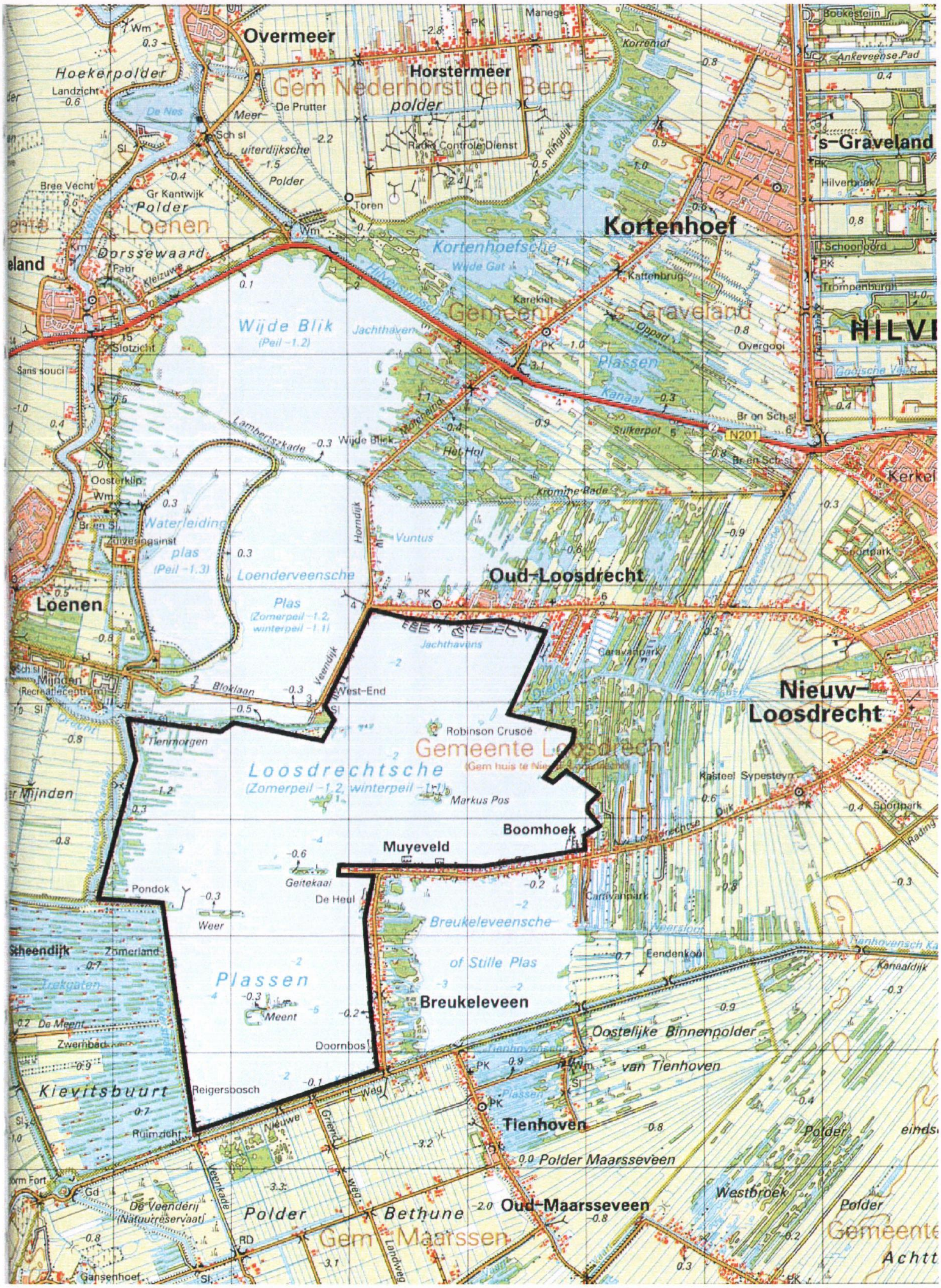
4 Description of Case Study Area (3 pages)

4.1 Geology, Topography and Hydrology

[Please briefly consider the geology, topography and hydrology of the catchment. Include information from summary table and provide further detail and explanations on: type of water; surface of the catchment in km^2; length [in km] or surface size [in km^2] of the water; mean discharge in [m^3 per second] or total water volume [in m^3]; altitude; depth; salinity and tidal range; describe seasonal and other variations in flow and any other important aspects of flow dynamics. Maps showing the river network, coastal length should be provided.]

Lake Loosdrecht is typical of Dutch peat lakes (Hofstra & Van Liere, 1992). It is part of a system of shallow, interconnected lakes; the Loosdrecht lakes, including Lake Loosdrecht, Lake Breukeleveen, Lake Vuntus and Kievitsarea (see figure 4.1). It lies in the centre of the Netherlands in the province of Utrecht in an area of *Sphagnum* peatland. Lake Loosdrecht is bordered by the River Vecht to the West, Lake Eastern Loenderveen to the North, the Pleistocene ice pushed sand ridge to the East and Polder Bethune and Tienhoven lakes to the South. The total water area of the lakes is 10 km^2. The mean depth is 1,85m and the total water volume is $\pm 20*10^6$ m^3. The catchment area is 44 km^2. The hydraulic retention time is about 5-6 months. The water level is more or less fixed: it fluctuates between –1,07 m NAP and –1,15m NAP.

Figure 4.1 Map of the Loosdrecht lakes. The large water body with the black border is Lake Loosdrecht



4.2 Socio-Economic Geography and Human Activities in the Catchment

[Please describe the case study area, including maps. Please consider the (socio-economic) geography of the catchment. Include information from summary table (chapter 2) and provide further detail and explanations on: population in the catchment [number] and population density [in persons per km²]; explain distribution of population and identify the most important centres of population; describe the most important economic activities and water uses in the catchment and their impacts on the water body and adjacent aquatic and terrestrial ecosystems (in quality, quantity and morphology).]

The main function of Lake Loosdrecht is recreation. With 29 yacht-basins and an amount of ± 12.000 yachts during the summer period, the area has the largest watersport intensity of the Netherlands. Next to yachting, recreational fisheries is important. On the neighbouring marshes and nature areas recreational biking and hiking takes place. Another function of the lake is commercial fisheries by some fisherman on eel and pikeperch.

Human activities in the catchment are:

- drinking water extraction in the neighbouring Bethune polder;
- agriculture in the neighbouring polders;
- habitation: at the border of almost the whole lake there are large villa's, because it is very attractive to live along the lake.

4.3 Identification of Water Bodies

[Refer to HMW paper 7 ver 2 and the WFD Annex II, 1.2 "Ecoregions and Surface Water Body Types" for detail; if possible provide information according to either system A or system B.

This section should identify the water bodies within the study area. The description of water bodies should define the extent of the impact of the physical modification (i.e. it should include the unaffected water body immediately upstream and downstream).

Depending upon the circumstances, the impacts of a pressure may affect one water body or a series of water bodies.

If necessary, please group the water bodies according to different pressures and physical alterations. Please identify each water body clearly and group the water bodies according to the types of pressures to which they are subject (see table 2).

The following Table 4.2 serves as an example for grouping water bodies and indicating which sections (Part II, Part IIa) they refer to. You could use it for grouping the water bodies of your case studies, if you think such a grouping is useful. Please note that the separation is optional and only useful where there are fundamentally different pressures and physical alterations that affect distinct water bodies in your case study area. It is to avoid having more than 2 (or max. 3) different groups (and accordingly Parts II).

In this section the lake has to be divided in waterbodies on the basis of:

- **Application of the typology system** as defined in Annex II. This will split rivers into units based upon system "A" or "B" which will define the type-specific hydromorphological and physicochemical conditions. According to system A, Annex II of the WFD, Lake Loosdrecht:
    - is situated in one ecoregion, the Central plains;
    - the altitude typology is lowland (<200 m);
    - the mean depth of the lake is 1,85m, thus the class is < 3 m;
    - the size of the lake is 10 km^2 ; the class is 10 to 100 km^2;
    - the geology is organic.

  The application of the typology system does not lead to the identification of different waterbodies.
- **Definition of hydromorphological units** (e.g. major physical divisions - separate tributaries, main river stretches between large tributaries). The lake in this case study is a typical lowland shallow peat lake. No different hydromorphological units can be identified.
- **Effective management unit,** taking into account the pressures and resultant impacts. Lake Loosdrecht is managed by the waterboard Amstel, Gooi & Vecht. The province Utrecht and Noord-Holland are both responsible for this lake at the provincial level. The policy function of Lake Loosdrecht is nature with recreation. Formerly the drinking water company of Amsterdam, GWA, has used Lake Loosdrecht to transport the drinking water extracted from the Bethune polder in the direction of Amsterdam. Since 1959 the drinking water is transported through a separate canal to the drinking water reservoir in Lake Loenderveen. However, at present water from the Bethunepolder is still let in to Lake Loosdrecht to maintain a certain water quality (reduction of the chloride concentration).
- **Type specific biological condition** (e.g. the degree to which the waterbody forms a consistent ecological type, in terms of ecosystem structure and function). The ecological type of the reference condition of Lake Loosdrecht is an oligotrophic shallow lake (see information in Box 1 on the different types of shallow lakes and Box 3 on the reference condition of Lake Loosdrecht). Presently, lake Loosdrecht is an eutrophic shallow lake due to human impact. There exists both national and regional policy targets for Lake Loosdrecht. Furthermore, national standards for surface waters apply to the lake. In tabel 4.1 the values of the standards and targets are described. According to the national typology of target situations for nature (natuurdoeltypen, Verdonschot (2000)), Lake Loosdrecht would belong to the community of mesotrophic pools and lakes. The regional target situation for Lake Loosdrecht is to achieve a high ecological level; the abiotic target values belonging to a high ecological level are represented in table 4.1.

The values between the national and regional target differ somewhat, as the regional standards have been developed specifically for Lake Loosdrecht and the national target applies to all oligo-mesotrophic pools and lakes. The national standard values are less severe and allow more human impact than the national and regional target values.

Table 4.1 The values of the regional and national target and the national standard for Lake Loosdrecht

	NH_4	NO_3	totN	O_2	totP	pH	PO_4	Chlorophyll	transparency
date	mgN/l	MgN/l	mgN/l		mgP/l		mgP/l	mg/m^3	m
Regional target for Loosdrecht	<0,05	<0,05	<0,8	>6 mg/l	<0,05	6-8	<0,02	<10	>4/soil
National target for oligo-mesotrophic pools and lakes (natuurdoeltype)	<0,04	0		80-120%		5,5-6,6	<0,007		
National standard			2,2	5	0,15	6,5-9		100	0,4

On the basis of the four abovementioned criteria, we distinguish one waterbody: Lake Loosdrecht. The main pressures are flood protection, drinking water, recreation and water management.

Table 4.2 Details on separate groups of water bodies

Name of the group	Main pressures of the group	Main physical alterations of the group	Water bodies of the group	Section referring to the group	page numbers
Group 1	– Flood protection – Drinking water – Recreation (mainly sailing and fisheries) – Water management (nutrient loading of inlet water)	– Drastic change of hydrology of lake and consequently its water quality – Construction of unnatural embankments	Lake Loosdrecht	Part II (included in the HMWB TOR file)	

Box 1. Types of biological condition of shallow lakes

Shallow lakes can be distinguished in three biological types based on their nutrient richness:

- Oligotrophic shallow lakes having very low nutrient concentrations a low biological diversity and low biomass. An example of an oligotrophic lake were Lake Loosdrecht after its creation;
- Mesotrophic shallow lakes having moderately high nutrient concentrations and a moderately high biomass. These types of lakes have the highest biological diversity. Examples of these lakes are Lake Naardermeer and Lake Stichtse Ankeveen;
- Eutrophic shallow lakes having high nutrient concentrations, a high biomass and a low biological diversity. In the Netherlands a large number of lakes are presently this type of biological condition due to eutrophication. There are however lake which are eutrophic by nature, such as the Brasemermeer, called the bream lake because of its high biomass of bream.

A map should be provided showing the water bodies relative to the modified characteristics. This section should include discussion of:

- the main issues which were considered important in identifying the water bodies;
- any problems experienced in identifying the water body;
- comments on the level of differentiation (minimum size of water body) which was considered appropriate.

4.4 Discussion and Conclusions

[Discuss lessons learned, any problems encountered and how they were overcome.]

Difference between artificial and heavily modified

Numerous lakes in the Netherlands are created due to large human influence. The difference between an artifical or a heavily modified water is therefore not always clear. With regard to Lake Loosdrecht, the preconditions for the creation of lake have been made by industrial peatmining. Subsequent wind and wave action eroded the rest of the peatbanks and a system of shallow, interconnected lakes originated. We defined the difference between artificial and heavily modified in the following way:

- In case the water has been dug by humans, the waterbody is artificial (e.g. canals, pools for swimming, pools resulting from mineral extraction). The question remains then to hat extent the water body has to be dug (partially or completely).

- In case human activity has made the preconditions for creation , but the water body has not dug by humans, the waterbody is heavily modified.

If the criterium of digging of the waterbody still does not lead to a clear difference, a second criterium is applied: the existance of a natural reference condition on the basis of a comparable waterbody. If a natural reference condition applies to that water body, it is HMW. In case there exists no natural reference condition for that water body, as it differs too much from natural waters, the water is artificial. On the basis of these two criteria, Lake Loosdrecht is Heavily modified.

We would appreciate if the future guidance will provide clear criteria for determining the difference between artificial and heavily modified.

Selection of the correct scale of waterbodies

The selection of the correct scale of waterbodies is unclear. In this case studies on Lake Loosdrecht there are a number of connected or neighboring lakes, which have a comparable hydrology and pressures and impacts, but the ecology is not completely identical in the different lakes. The question is if the lakes should be selected as different water bodies or as one water body.

PART II

5 Physical Alterations (5 pages)

5.1 Pressures and Uses

[This chapter should provide detailed information on significant pressures on the water bodies, i.e. the economic and social forces that create pressure on the water bodies. See HMW paper 5 ver 3, nr. 3 for the terminology concerning pressures.]

The pressures and uses of the lake and catchment are:

- Agriculture leading to:
    - diffuse pollution;
    - reclamation of low-lying polders Bethunepolder, Horstermeerpolder and Flevopolder leading to changes in hydrology and a reduction of nutrient poor seepage water into the lake.
- Urbanisation leading to:
    - diffuse and point source pollution from the surrounding households;
    - reclamation of low-lying polders Bethunepolder, Horstermeerpolder and Flevopolder leading to changes in hydrology of the catchment and a reduction of nutrient poor seepage water into the lake.
- Watersupply: Drinking water is extracted at the infiltration area Utrechtse sand ridge and from the seepage water of the Bethune polder. The extraction at the Utrechtse Heuvel has a volume of ±5,2 million m^3/year in the year 2000 (pers.comm. PWN). From the Bethunepolder ±27 million m^3/year seepage water is extracted (data from 1994, W+B, 1997). This groundwater extraction leads to changes in the hydrology of the catchment and a reduction of nutrient poor seepage water into the lake.
- Flood protection and water management leading to:
    - unnatural water level management: Lake Loosdrecht has a nearly fixed water level to protect the remaining peatbanks from crumbling away, protect the neighbouring habitation of being flooded during wet periods and enable sailing with yachts during dry periods;
    - inlet of "allochtonous" (gebiedsvreemd) water into the lake to attain a fixed water level. The "allochtonous" water is dephosphorized water from the Amsterdam-Rhine canal. Due to infiltration in the lake the water level decreases and water has be let in.
- Recreation leading to:
    - diffuse and point source pollution from the surrounding yacht-basins, camping sites, restaurants etc.;
    - disturbance of the fauna and flora in and around the lake by the sailing of yachts and the recreational fisheries;

- construction of unnatural embankments at yacht-basins and havens;
- resuspension of silt by the sailing of yachts, which leads to an increase of turbidity.

- Commercial fisheries by some fishermen.

5.2 Physical Alterations

[This section should refer to the physical alterations which result from the above pressures (See HMW paper 5 ver 3, nr. 4-9 for terminology on physical alterations). This should include reference to alterations to the water bed, banks and riparian zone. Photographs, maps, plans, graphs and tables should be produced as required. In particular, please discuss the types of physical alterations, which are considered to be relevant/appropriate. These may include:

- direct physical alterations upon river channel or bed such as river straightening;
- alterations resulting from pressures upon riparian zone such as flood defence ;
- indirect physical alterations such as drainage work on adjacent land;
- others ....]

The direct physical alterations to the lake are:

- construction of unnatural embankment along almost the whole lake for recreational purposes and to protect the remaining peatbanks from crumbling away;
- creation of artificial islands with sediment of Lake Loosdrecht for recreational purposes.

Indirect physical alterations:

- reclamation of the Flevopolder in ±1950-60;
- reclamation of the neighbouring, low lying Bethune polder and Horstermeerpolder;
- inlet of "allochtonous" water, namely dephosphorized water from the Amsterdam-Rhine canal.

5.3 Changes in the Hydromorphological Characteristics of the Water Bodies and Assessment of Resulting Impacts

[Describe the hydromorphological changes, which result from the direct physical alterations. For example:

- change in flow regimes and the consequent impact upon downstream channel morphology (e.g. connected to interrupted sediment transport);
- lake water level regulation and the impact on lake basin morphology;
- artificial flow regime and the impact on riparian vegetation and bank morphology ;
- others ...]

The changes in hydrology are:

- A decrease of phosphate poor seepage water into the lake because of the reclamation of the neighbouring and low lying Bethune polder and Horstermeerpolder and other polders, drinking water extraction in the infiltration area Utrechtse Heuvelrug and the reclamation of the Flevopolder. Presently, water infiltrates into the bottom and leaves Lake Loosdrecht.
- The inlet of "allochtonous" (gebiedsvreemd) water into the lake in order to maintain the fixed water level, namely dephosphated water from the Amsterdam-Rhine canal. In addition seepage water of the Bethune polder is let in as well, however this water resembles the groundwater which seeped directly into Lake Loosdrecht in former times (period 1800-1920). Before 1984 strongly polluted Vechtwater had been let into the lake. The high nutrient load of the Vechtwater has led to eutrophication of the lake. To restore the lake, the Vechtwater has been replaced by water from the Amsterdam-Rhine canal used with a P-removal before entering Lake Loosdrecht.
- An unnatural water level management: Loosdrecht has a nearly fixed water level to protect the neighbouring habitation of being flooded and optimise the conditions for recreation.

Change in morphology:

- Construction of unnatural embankment along almost the whole lake.
- Creation of artificial islands in the lake.
- Eutrophication has led to a layer of organic silt on the sediment, which comes easily into resuspension due to wind, recreational activities and movements of fish feeding on the sediment.

5.4 Discussion and Conclusions

[Discuss lessons learned, any problems encountered and how they were overcome.]

Lake Loosdrecht has been impacted by numerous human uses and even impacts outside the catchment have led to drastic hydromorphological and ecological impacts in the lake.

The reclamation of polders and ground water extraction occuring outside the catchment of Lake Loosdrecht have caused changes in the groundwater hydrology leading to different patterns of seepage and infiltration. This observation has the following consequences:

- The measures needed to restore the former groundwater hydrology pattern have to be taken outside the catchment of the river basin management plan (borders are based on surface water hydrology). The water authorities of the lake have presently in most cases no authority to take measures in the area outside the catchment. However, the WFD states that measures in a catchment may not have a negative impact on other catchments.
- Groundwater measures should not only be assessed on their impact on the groundwater quantity and quality, but also on their impact on the surface water bodies.
- Certain historic changes are irreparable, as original groundwater flows or -quality have been changed and can not come back in their original form.

6 Ecological Status (7 pages)

[In this chapter, please describe the current ecological status of the water body, following the structure of WFD Annex V, 1.1 "Quality Elements for the Classification of Ecological Status". Refer to HMW paper 6 ver 2.]

6.1 Biological Quality Elements

[Please describe briefly the current ecological condition of the water body (with more detail provided below). It will be important to discuss the following aspects:

- The range of biological measurements (phytoplankton, macrophytes, phtytobenthos, macroinvertebrates, fish fauna) used and the extent to which it is considered that they adequately reflect the pressures resulting from the physical modification upon the water body. Would additional measurements be needed in the future? Shortfalls in the information available should be highlighted here and proposals for additional measurements should be suggested.
- The extent to which the impacts upon biology are a consequence of the physical alterations. Both upstream and downstream impacts should be described. Are other pressures (such as pollution) important? How can such pressures be separated?]

Available data on biological quality elements are:

- phytoplankton concentration in 2000 (see figure 6.1 and table 6.1 with chlorophyll values);
- cover of the macrophytes Chara, Potamogeton and Elodea (see figure 6.2 and 6.3);
- fish stock in number and amount of different species (see figure 6.4).

The chlorophyll data exceed the regional ecological standards of the waterboard (see table 6.1). The macrophyte coverage of Chara and Potamogeton is very low in the open water. The macrophytes occur only in the surrounding marshes. Due to the high turbidity of the water, the light climate is unsuitable for the development of waterplants. The fish stock is dominated by the preyfish Bream and Roach. The preyfish has been mainly found in the open water. The most important predator fish is Pikeperch (see also figure 6.2 and 6.3).

Figure 6.1 Chlorophyll concentration between 1997-2001 (Source: DWR)

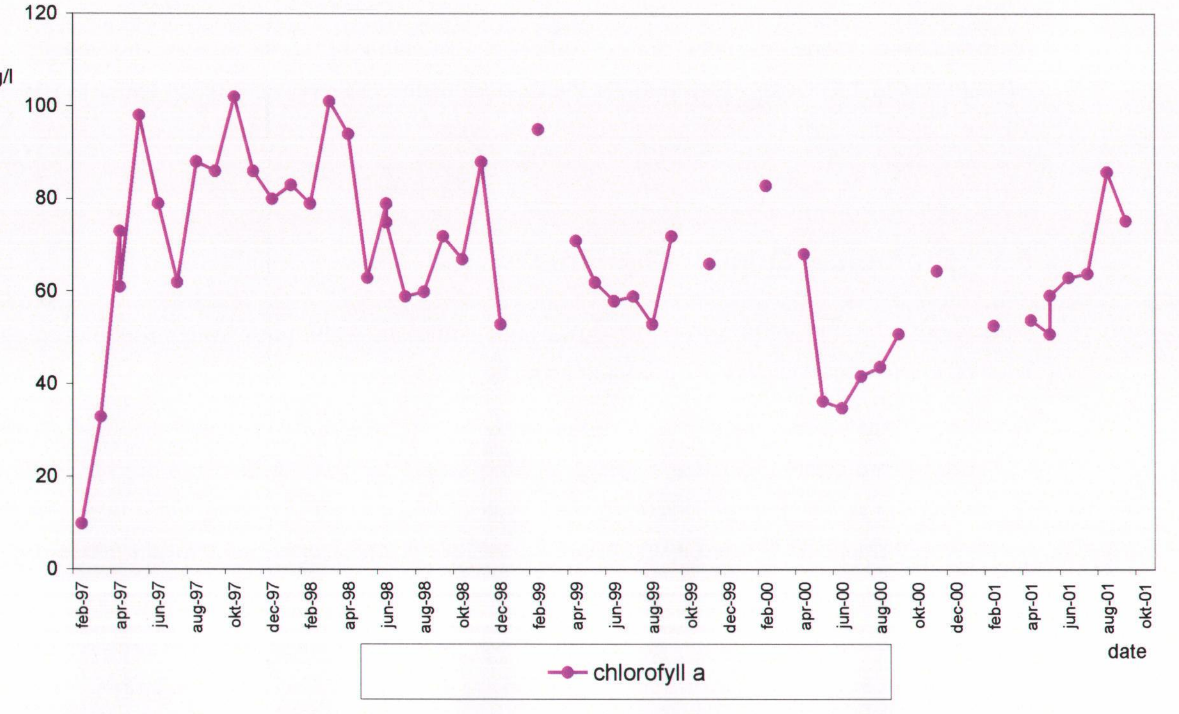


Figure 6.2 Cover of the macrophyte Chara (presented in red colour) (Source: province Utrecht

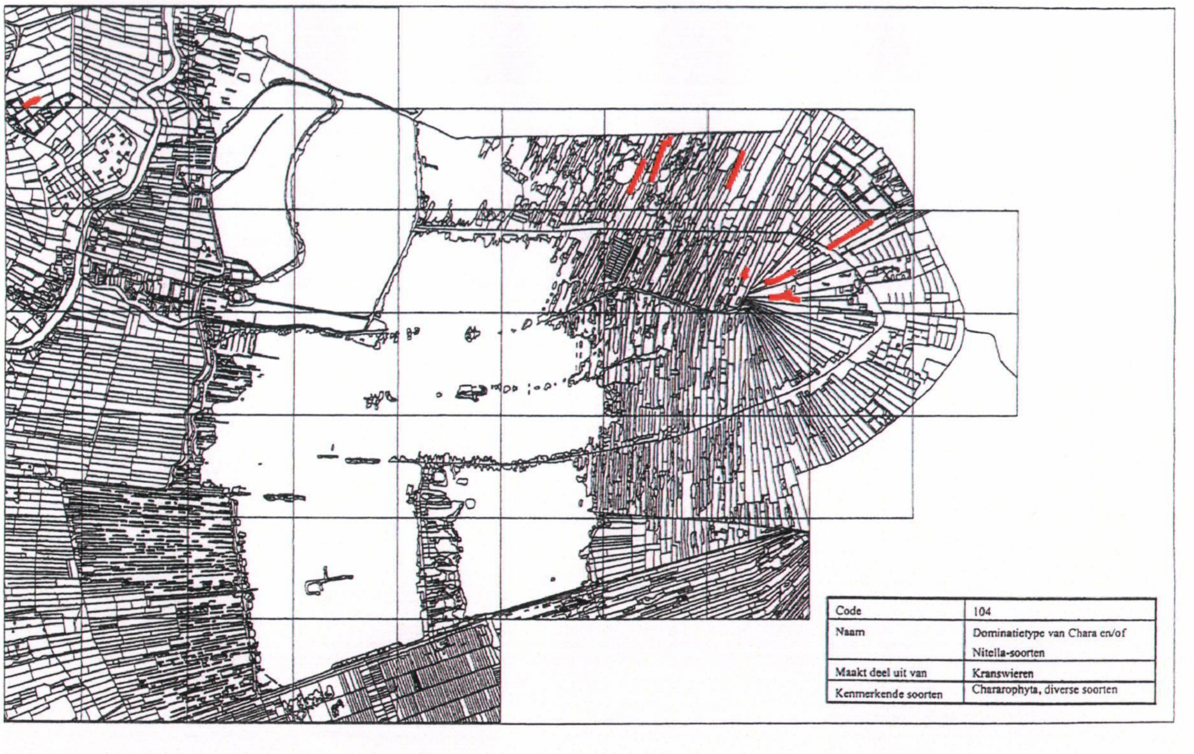


Figure 6.3 Cover of the macrophytes Potamogeton and Elodea canadensis (presented in red colour) (Source: province Utrecht)

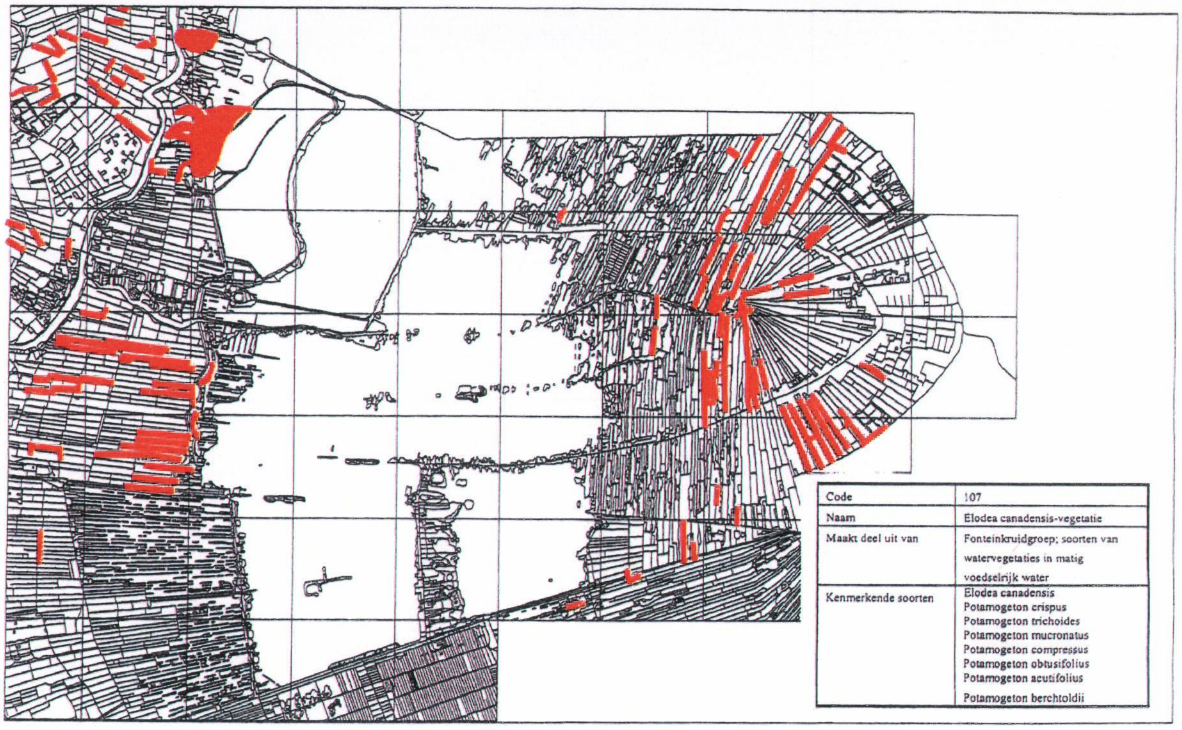
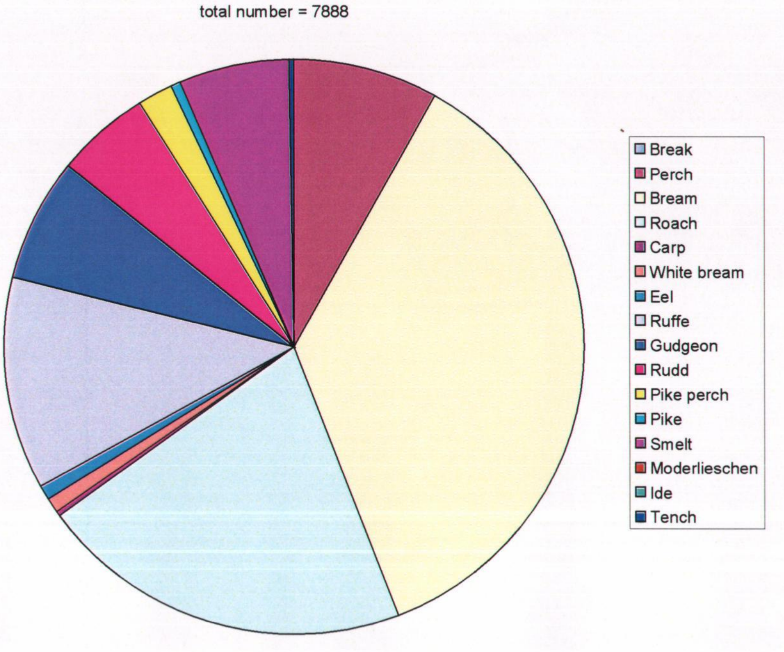
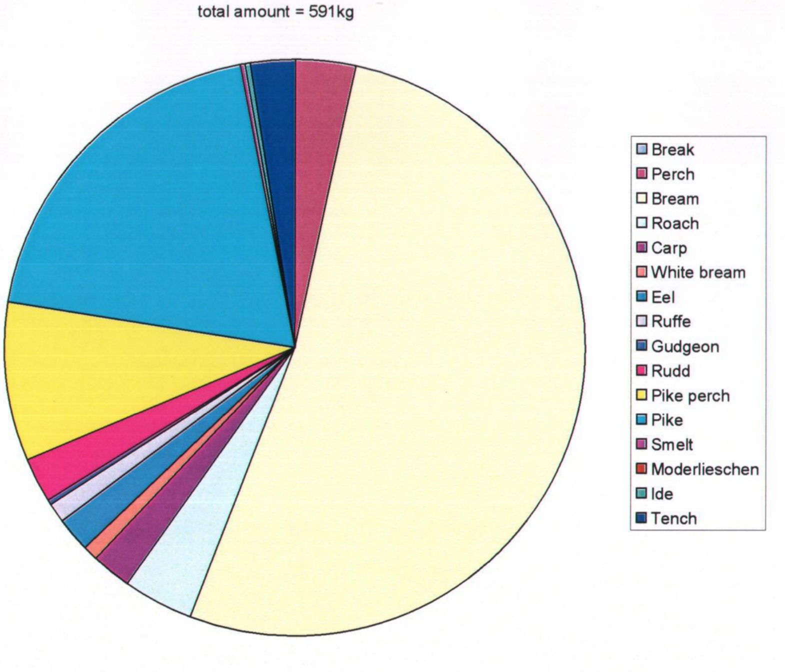


Figure 6.4 Fish stock of Lake Loosdrecht in number and amount of different fish species (Source: OVB, 2001)





The biological parameters algae, macrophyte and fish indicate that Lake Loosdrecht is eutrophicated.

6.2 Physico-Chemical Elements

[Does the physical alteration have an impact upon the physico-chemical elements? Examples of such impacts are:

- low oxygen levels because of straightened and deepened channel;
- low temperature because of discharge of the dam, etc.

Describe the scale of the change in physico-chemical elements in the context of other pressures (e.g. pollution).]

The values of the year 2000 of the physico-chemical parameters measured in Lake Loosdrecht are shown in table 6.1. The development of the nitrogen, phosphate and transparency values between 1997 and 2001 are shown in the figures 6.6, 6.7 and 6.8. Most nutrient values, the algal concentration and the transparency values exceed the regional target set for Lake Loosdrecht (see table 4.1). Next to the biological parameters, described in paragraph 6.1, the physico-chemical parameters indicate also that the lakes are severely eutrophicated

Table 6.1 The values of the year 2000 of the physical-chemical parameters measured in Lake Loosdrecht. Bold value: measured value exceeds the regional target values. (Source: DWR)

	KjN	NH_4	NO_3	totN	O_2	totP	pH	PO_4	Chloro-phyll	transpa-rency
date	mgN/l	mgN/l	MgN/l	mgN/l	mg/l	mgP/l		mgP/l	mg/m^3	m
10-01-00					**4,6**	**0,057**	**8,35**			**0,4**
03-02-00	1,89	**0,12**	**0,26**	**2,17**	8,5	**0,057**	**8,38**	0,01	**82,9**	**0,5**
02-03-00					11,6	**0,059**	**8,46**			**0,2**
14-04-00	1,86	**0,05**	**0,1**	**1,97**	10,4	**0,066**	**8,49**	0,007	**68,1**	**0,5**
12-05-00	1,57	**0,05**	**0,1**	**1,699**	8,5	0,048	**8,39**	0	**36,4**	**0,6**
07-06-00	1,29	**0,05**	**0,1**	**1,4**	7,9	**0,06**	7,99	0,005	**34,9**	**0,6**
04-08-00	1,26	**0,086**	**0,1**	**1,37**	7,3	0,03	**8,55**	**0,024**	**43,8**	**0,5**
08-09-00	1,44	**0,05**	**0,1**	**1,55**	9,2	0,039	**8,36**	0,005	**50,9**	**0,7**
29-09-00					9,1	0,039	**8,52**			**0,4**
26-10-00					10,1	**0,05**	**8,35**			**0,6**

Figure 6.5 Nitrogen concentration in Lake Loosdrecht between 1997 and 2001 (Source DWR)

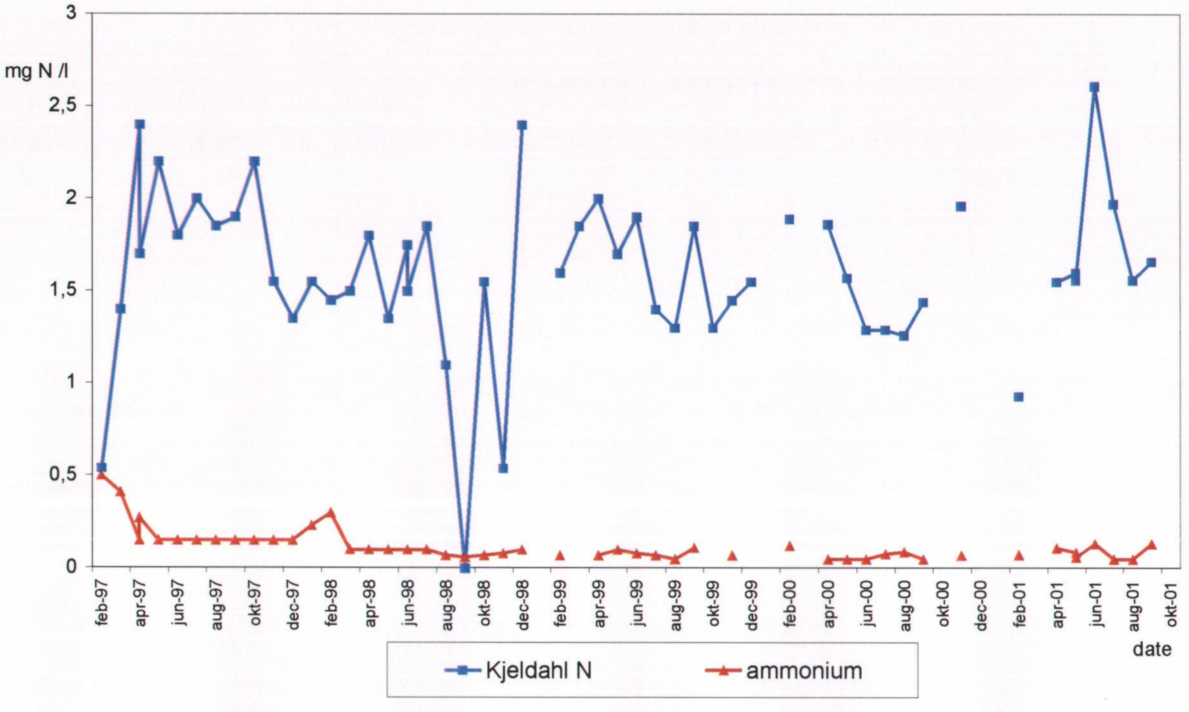


Figure 6.6 Phosphate concentration in Lake Loosdrecht between 1997 and 2001 (Source: DWR)

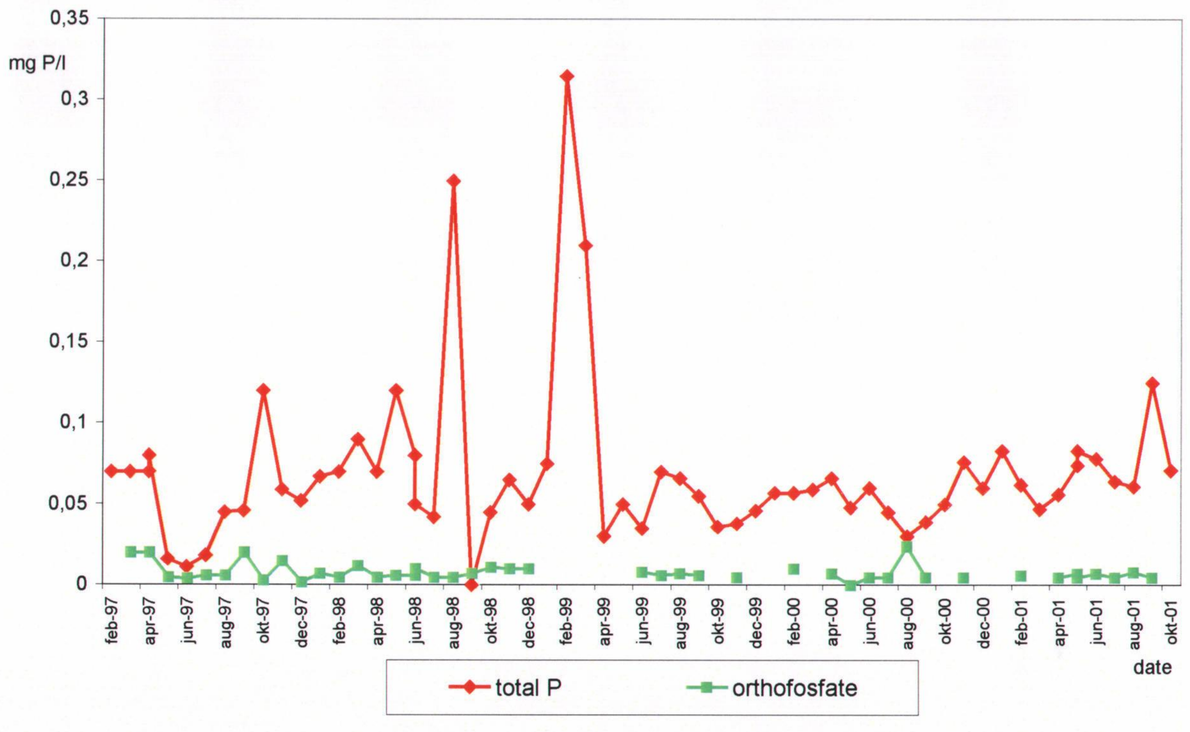
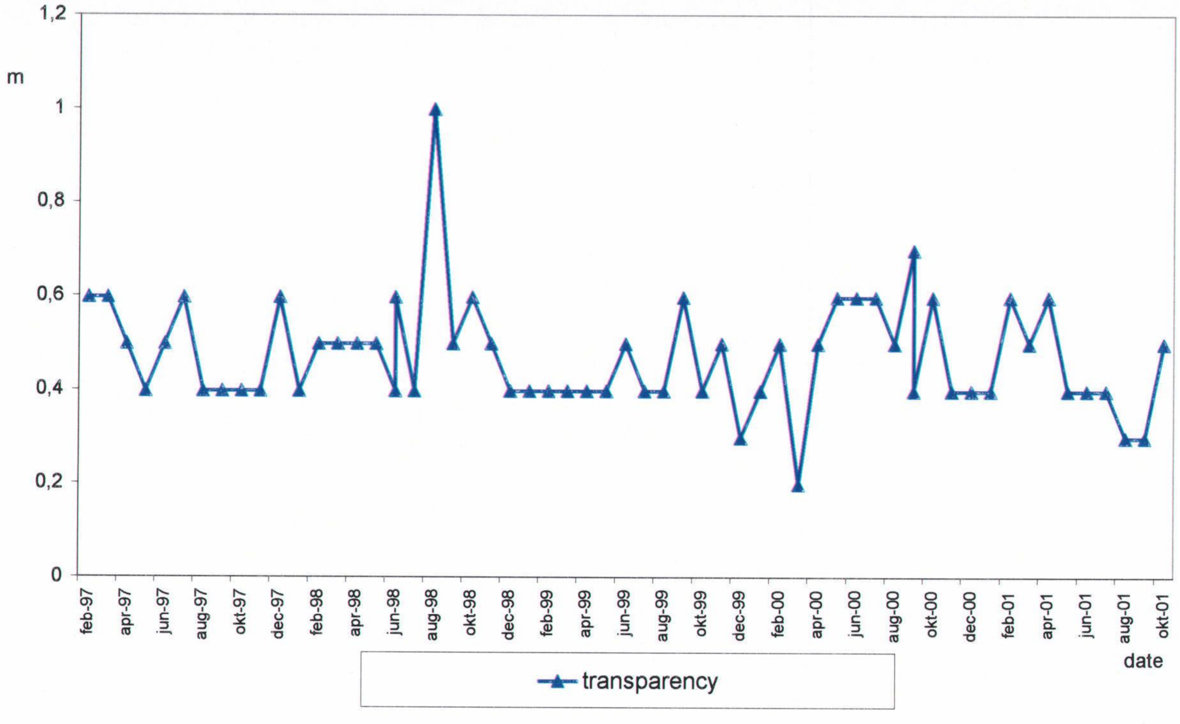


Figure 6.7 Transparency in Lake Loosdrecht between 1997 and 2001. (Source: DWR)



6.3 Definition of Current Ecological Status

[How have the physico-chemical and biological quality elements been brought together in order to define ecological status?

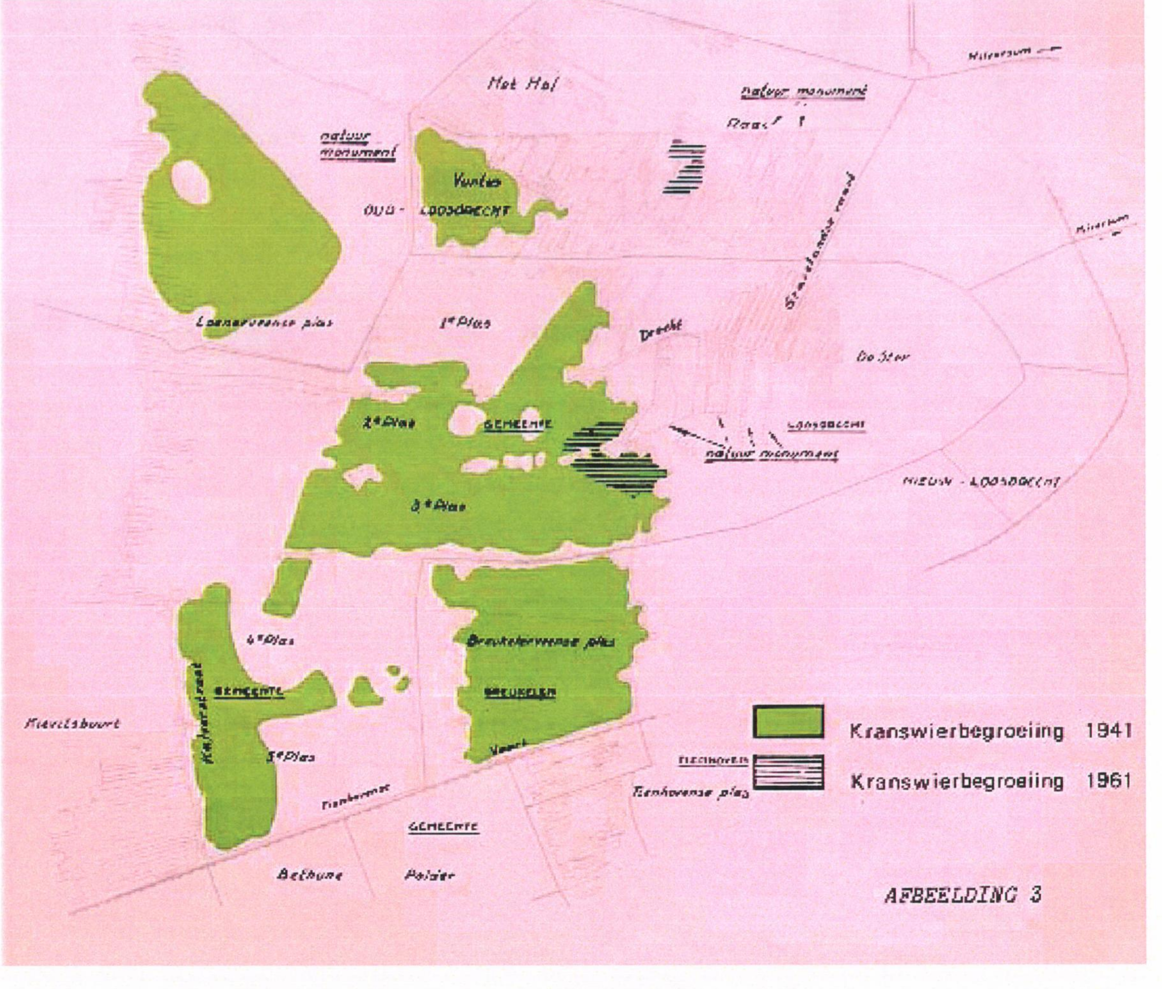
Has this been done using an existing classification or using expert judgement?

Is it considered a good approximation to the definition of good ecological status as defined by the directive - what are the weakness in the current definition?]

Both biological and physico-chemical parameters show that the lake is eutrophicated. The reference condition of the lake was clear and very oligotrophic (see Box 3 on the selection of a reference of Lake Loosdrecht). On the basis of expert-judgement the current ecological status is classified as the lowest ecological level (laagste ecologisch niveau) (based on national classification method).

The theory on eutrophication of shallow freshwaterlakes (Scheffer, 1999) states that these lakes have two equilibrium situations: a clear, meso-oligotrophic condition and a turbid, eutrophic condition (see Box 2 on eutrophication of shallow lakes). In former times Lake Loosdrecht was clear and very oligotrophic (±1920). The biomass and diversity of flora and fauna was very low due to nutrient limitation. In the period 1930-1955 the change of the hydrology of the lake (decrease of phosphate poor seepage water into the lake and inlet of seepage water from the Bethune polder and surface water of the river Vecht) transformed the oligotrophic lake to a mesotrophic clear lake with macrophytes (see figure 6.8 with historic data on macrophyte cover). After 1955 the nutrient concentration in the Vechtwater increased drastically and the inlet of this nutrient-rich Vechtwater in the period 1955-1984 is the major cause for the eutrophication of Lake Loosdrecht. A number of restoration measures have been taken to switch the equilibrium from a turbid to a clear lake. However, at present the lake is still turbid. This turbidity prevents the recovery of the lake into a clear, macrophyte dominated lake, as the light is limiting the growth of macrophytes. The turbidity is an inheritance of the past. Eutrophication has created a layer of very small, organic silt on the bottom of the lake, which comes easily into resuspension due to wind, recreation activities and movements of the benthivorous fish feeding on the sediment. This inheritance of the past leads to a hysteresis effect: the phosphate level needed for a clear lake has to be lower than in the clear water period before eutrophication (see also the theory explained in Box 2). The present phosphate levels should in theory be low enough for a clear lake, but due to the resuspension of the silt the lake still remains turbid.

Figure 6.8 Historic map of the macrophyte cover of Chara in 1941 and 1961



9 **Box 2 The theory on eutrophication of shallow lakes (Scheffer, 1999)**

This section summarises the ecological theory of eutrophication of shallow lakes. The predominant effect of increased nutrient loads into lakes is eutrophication, which involves a cascade of direct and indirect effects (Klinge et al., 1995, Janse & Van Liere, 1995, Hosper 1997, Scheffer 1998). This cascade of effects can lead one of the two equilibrium states of shallow lakes ; a turbid, phytoplankton dominated lake in a meso- or eutrophic state. The other equilibrium state is a clear and macrophyte dominated lake, which is in a meso- or oligotrophic state. The balance between these two states depends on two forces (Klinge et al., 1995):

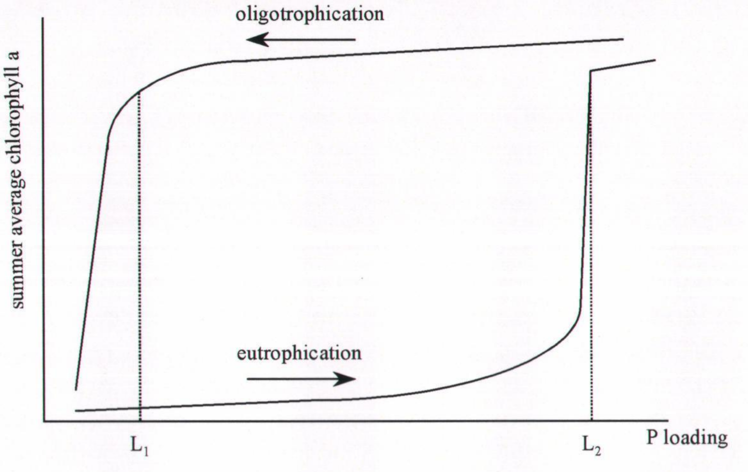
- a bottom up force determined by producers, such as algae, zooplankton and plankti- and benthivorous fish. The potential biomass at different trophic levels, including the production of preyfish, is determined by the nutrient richness of the system;
- a top down force determined by consumers, such as predatory fish. The actual biomass and community structure are considered to depend mainly on consumer-control.

In shallow lakes (mean depth 1-4 m) high nutrient levels can lead to increased primary production of phytoplankton. The higher algal biomass increases the turbidity of the water and increases oxygen demand of the sediment due to decomposing algae. The turbidity can lead to a decline of submerged macrophytes. Macrophytes have clearing effects on the water, because they 1) provide refuge to grazing zooplankton; 2) protect the sediment from resuspension and 3) provide a habitat and hiding place for predatory fish, feeding on plankti- and benthivore fish. Turbid lakes devoid of vegetation have few predatory fish and have a high abundance of plankti- and benthivorous fish. Abundant planktivore fish control the zooplankton, resulting in low grazing of algae. Benthivore fish cause resuspension of sediment, increasing both turbidity and phosphate release from the sediment.
The biomass of predatory fish depends heavily on the morphometric conditions of the lake. These morphometric conditions determine the availability of suitable habitat for the predatory fish, such as submerged vegetation and emergent plants. The area of suitable habitat determines the maximum biomass of predatory fish and thereby the top down force of preyfish consumption. This area of suitable habitat has declined in the Netherlands due to a number of causes. Next to eutrophication, leading to turbidity and the disappearance of macrophytes, the application of artificial (high in summer and low in winter) or stable waterlevels, embankment of natural banks and floodplains have lead to a reduction of submerged and emergent vegetation.

The transition between these states is characterised by a so-called hysteresis effect (figure 6.9). The hysteresis effect implies that there are different threshold nutrient loadings for transitions between the two equilibrium states, namely the critical nutrient loading for transition is lower, if the lake is in an eutrophic state than in a mesotrophic state. This is illustrated by L1 and L2 in figure 3. Hysteresis is caused by a number of physico-chemical (e.g. nutrient release from sediment, wind-induced resuspension of sediment in plant free lake) and ecological processes (e.g. increase of turbidity and nutrient release due to sediment perturbation by benthivore fish, dominance of non-consumable blue green algae at high turbidity) (Scheffer 1998, Hosper 1997). These processes cause a certain resistance to change with increasing and decreasing nutrient loading untill the loading is high or low enough to cause a switch to another equilibrium state (Hosper 1997). The difference in threshold nutrient loading between oligotrophication and eutrophication depends on lake characteristics and the application of restoration measures.

Lake characteristics are the depth of the lake, its retention time and sediment characteristics. Restoration measures can change the lake characteristics (e.g. flushing of lakes, lowering water level) or suppress the hysteresis effect (e.g. removing white fish and introducing predatory fish, dredging sediment).

Figure 6.9. A graphic representation of the hysteresis phenomenon in a lake, in which the eutrophication process has a different relationship of chlorophyll versus phosphate loading compared to the oligotrophication process (Figure adapted from Janse & Van Liere, 1995, Hosper 1997 and Scheffer 1998)



Box 3 Reference situation and history of Lake Loosdrecht

In the history of the Loosdrecht lakes a number of phases can be distinguished (Hofstra & Van Liere, 1992):

Phase 0: creation of Loosdrecht lakes in ±1700
Before their creation the lakes were Sphagnum peat marsh. The preconditions for the creation of the Loosdrecht lakes have been made by human activities. In medieval times the land was drained for agricultural purposes. In 1633 industrial peatmining started and the peat was dredged from underneath the watersurface and left to dry on adjacent banks. In this way an area with cuts ("trekgaten") and banks ("legakkers") was formed. Continuing peatmining led to smaller banks and subsequent wind and wave action eroded the banks. A system of shallow, interconnected lakes originated.

Phase 1: 1800-1920
The lake was a strongly nutrient-limited, oligotrophic lake. It was mainly fed by phosphate poor seepage water from the infiltration area Utrechtse Heuvelrug. The phosphate concentration in 1920 was 5,4µg/l.D due to nutrient limitation the lake had a low biodiversity and biomass. Submerged waterplants were vitually absent, only at the border and on the banks grew some macrophytes. The fish diversity was low, the population was dominated by the species Pearch and Roach. The estimated fish biomass was 50kg/ha.

Phase 2: 1930-1955

The lake was a nutrient-limited, mesotrophic lake, dominated by submerged macrophytes. The change of the hydrology of the lake (decrease of phosphate poor seepage water into the lake and inlet of seepage water from the Bethune polder and surface water of the river Vecht) increased the nutrient load into the lake. The water was clear and the lake had a well-developed submerged vegetation of Characeae in the open water and Potamogetanaceae at the borders. The amount of zooplankton was relatively large compared to phytoplankton. The estimated fish biomass was ±250 kg/ha ; the dominant species being pike and bream. The annual average chlorophyll concentrations are about 25 mg/m^3 , the total P values are ± 0,0055 mgP/l, the summer average mineral nitrogen concentration is about 17 µmol/l.

Phase 3: 1960-1980

The lake was a light-limited, eutrophic lake, dominated by cyanobacteria. The drastic increase of the nutrient concentration in the Vechtwater has caused the eutrophication of the lake. The dense cyanobacteria growth limited the growth of submerged macrophytes due to light limitation. The fish biomass is ± 300 kg/ha, dominated by bream and pike-perch. The annual average chlorophyll concentrations are about 100 mg/m^3, the total P values are ± 0,1 mgP/l and the summer average mineral nitrogen concentration is about 60 µmol/l.

Phase 4: 1980-present

The lake is a eutrophic lake with a high internal phosphorus loading, dominated by detritus. Phase 4 is like phase 3, but seston (<150µm) is now dominated (50-75%) by detritus. This phase is a stable state of the lakes. Measures, that have been taken to reduce the external phosphorus loading rate to the Loosdrecht lakes (replacement of Vechtwater by dephosphated canal water), have resulted in only a small decline of the total P concentration since 1984. The ecosystem is apparently well-buffered against changes in external nutrient supply , due to high internal nutrient loading rates.).

We selected phase 1: the strongly nutrient-limited, oligotrophic lake as reference condition for Lkae Loosdrecht, because:

- it is the first phase after the creation of a shallow freshwater lake in its present form;
- it is a phase with little human impact. Phase 2: mesotrophic condition was the result of eutrophication of the inlet water and drinking water extraction, therefore this condition is not undisturbed and will not be selected as reference.

6.4 Discussion and Conclusions

[Discuss lessons learned, any problems encountered and how they were overcome.]

Availability of assessment method

There is no adequate, quantitative assessment method based on 5 classes available for lakes, because too few clear and mesotrophic lakes exist at present in the Netherlands. Moreover, an assessment method, which meets all the requirements of the WFD, has not been developed yet. Therefore, the ecological status has been derived on the basis of expert-judgement and the difference between the present situation and the reference condition.

Selection of reference condition

The selection of the reference condition is a crucial step in the HMW designation, as it determines how much the present ecological status differs from the good ecological status. If this difference is very small, the water body should be designated natural.

The reference condition is defined as the undisturbed condition of an ecological type of a certain water category. This definition means that the reference condition should not be defined for an individual waterbody, but for an ecological type. Inside an ecoregion more water bodies of that ecological type should exist. In case former hydromorphological changes have led to a change of water category (change from estuary to fresh water lake due to building of dam), the reference condition should be based on the new water category (undisturbed freshwater lake). This means that the reference condition is not based on an undisturbed historical situation, but on a spatial or theoretical based reference.

However, if the present policy aims to "remove" the former hydromorphological changes and to restore the former water category, then the reference condition should be based on the former water category and the reference condition can be historically based (e.g. the reference condition of the present lake Haringvliet is an estuary, as it has already been decided that the Haringvliet dam will be opened in the future).

Application of this definition of the reference condition on lakes in the Netherlands leads to the following observations:

A. Many lakes have different phases in history with a different level of hydromorphological impact and a different ecological condition of even a different water category. Therefore, it is not always very clear which phase is the undisturbed reference condition. The selection of a certain phase as reference condition has consequences for the designation as natural or HMW. This is examplified by Lake Loosdrecht :

- selection of oligotrophic condition in ±1920 as reference condition, means that the lake in its present condition can not reach the GES and is designated as HMW;

- selection of the mesotrophic condition in the period 1930-1955 as reference condition, means that the lake is near the GES before 2015 (applies only to the water body, not to the banks). The mesotrophic condition is the result of eutrophication of the inlet water and drinking water extraction, therefore this condition is not undisturbed and will not be selected as reference.

B. The ecological functioning of shallow freshwater lakes is the product of its hydromorphological environment. Especially in an undisturbed state (when the human impact such as eutrophication has been removed) the hydrology, morphology and ecology of each lake is very specific. For example, the oligotrophic reference condition of Lake Loosdrecht is the result of the creation of the lakes at that specific location as a result of human influence. A natural lake would never have been formed there. Therefore, it will be difficult to define a reference condition, that applies to a number of lakes. The risk is that either the reference condtion is too detailed and differs too much from the "real" undisturbed condition of a lake or the description of the reference is too general and is not suitable for ecological assessment of the lake.

7 Identification and Designation of Water Bodies as Heavily Modified (6 pages)

[Refer to HMW paper 7 ver 2].

7.1 Provisional identification of HMWB

On the basis of the physical alterations described in chapter 5 and the current ecological status described in chapter 6, Lake Loosdrecht is provisionally identified as Heavily Modified Waters.

7.2 Necessary Hydromorphological Changes to Achieve Good Ecological Status

[Here, the changes to the hydromorphological characteristics that would be (theoretically) necessary for achieving good ecological status should be assessed. Based on this, the effects these changes would have on the specified "Uses" shall be estimated and evaluated. [Article 4.3 (a). [1]

How have the required measures to achieve good ecological status been defined?

How has the impact of these measures on water uses been described?

How have "significant adverse effects" been defined (tools could range from simple descriptions of the consequences to economic analysis)? [2]

How have impacts upon the wider environment been assessed? This should include upstream/downstream effects, wider implications of mitigation measures - waste disposal or energy use.]

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[1] Article 4.3 (a) WFD. "*Member States may designate a body of surface water as artificial or heavily modified when: (a) the changes to the hydromorphological characteristics of that body which would be necessary for achieving good ecological status would have significant adverse effects on* [Uses]: *i) the wider environment, ii) navigation, including port facilities, or recreation, iii) activities for the purposes of which water is stored, such as drinking water supply, power generation, irrigation, iv) water regulation, flood protection, land drainage; or v) other equally important sustainable human development activities.*"

[2] Different methods for decision-making are:

- rule of thumb;
- expert assessment (incl. qualitative and quantitative data);
- direct consideration of "main" or dominant uses, involving political decision, public involvement and consensus among water users.

7.2.1 Required hydromorphological changes and required measures to achieve the Good Ecological Status

The undisturbed, reference situation of Lake Loosdrecht is the situation directly after the creation of the lake, which is phase 1; a strongly nutrient-limited, oligotrophic lake. To achieve the good ecological status, the present lake has to be restored to an oligotrophic lake with a low biodiversity and biomass.

The hydrological changes needed are:

The restoration of the former hydrology of the catchment, namely:

- restoration of the phosphate poor seepage water into Lake Loosdrecht coming from the hill ridge;
- stopping the inlet of seepage water from the Bethune water and dephosphated Amsterdam-Rhine canal water.

Change of fixed water level to a natural water level management is not a suitable restoration measure, as it will lead to losses of the remaining peat banks, which have a high ecological and historical value.

The morphological changes needed are:

- recovery of natural banks and marshes along the lake.

The required measures to restore the former hydrology of the lake and its catchment are to remove the causes for the change of the hydrology, namely:

- inundation of southern part of the Flevopolder;
- inundation of the neighbouring low-lying Bethunepolder and Horstermeerpolder;
- rise of the groundwater level of other neighbouring, low-lying areas leading to a wet, marshy area;
- stopping or reducing the drinking water extraction in the infiltration area at the Utrecht sand ridge.

Required measures to restore the former morphology are:

- removal of unnatural embankments and the large number of yacht-basins to enable return to natural banks and marshes.

7.2.2 Impact on water uses and significant adverse effects

- Inundation of southern part of the Flevopolder and of the low-lying Bethunepolder and Horstermeerpolder has a significant adverse effects on the functions of these areas:
  - The province Flevoland is a polder of 241.200 ha. It has 328.767 inhabitants in 6 municipalities. The land use of the Flevopolder consists mainly of agriculture (43% of total area). Next to agriculture, habitation and nature are major functions. It has been created after the Second World War to create space for habitation and agriculture in the densely populated Netherlands.
  - The Bethune polder is 540 ha and has ±200 inhabitants (pers.comm. Gemeente Maarssen). It is part of the municipality Maarssen. The main function is drinking water extraction for the city Amsterdam. Due to this function agriculture is confronted with restrictions and is mainly extensive. The flooding of the polder wil stop the drinking water extraction. Presently, ±27 million m^3/ year seepage water is extracted from the Bethunepolder (W+B, 1997). This is 30% of the drinking water need of the city Amsterdam.
  - The Horstermeerpolder is ±600 ha. The main land use is agriculture.
  - The groundwater level of other neighbouring, low-lying areas has to be risen leading to a wet, marshy area. This will lead to problems for the habitation in the neighbouring municipalities s'Graveland (9.261 inhabitants), Hilversum (82.177 inhabitants), Loosdrecht (8.808 inhabitants), Maarssen (40.293 inhabitants).
- The extraction of $5,2*10^6$ m^3/year drinking water (in the year 2000) in the infiltration area Utrechtse Heuvelrug has to be stopped, which is a significant impact on that use. As this extraction is the main drinking water source for the region Utrecht and het Gooi, stopping the extraction has a large impact on the drinking water supply of that region.
- Increased risk of water level problems for the habitation and camping sites bordering the lake in the towns Breukeleveen and Oud-Loosdrecht due to removal of fixed banks and dikes.
- Removal of the 29 yacht-basins, which will have a significant impact on the recreation function of the lake.

7.2.3 Impacts on the wider environment

The hydromorphological measures will change the whole ground- and surface water hydrology of the area, leading to higher groundwater levels and more natural surface water levels in the whole lake district of the provinces Utrecht and North-Holland.

7.3 Assessment of Other Environmental Options

[This section should consist of two parts and the first part defines the scope of the second:

- The first part should refer to the identification and definition of the beneficial objectives served by the modified characteristics of the water body [see Art. 4.3 (b))] [3]
- The second part should consider other alternatives to the existing "water use"[again see Art. 4.3 (b)]. There are three aspects to the test of Art 4.3 (b). Alternatives to the existing "water use" must:
  - be <u>technically</u> feasible;
  - not be <u>disproportionately</u> costly;
  - <u>reasonably</u> achieve <u>significantly</u> better environmental option.

How have these issues been addressed?

How wide has the assessment of options been?]

7.3.1 Identification and definition of the beneficial objectives served by the modified characteristics of the water body

- Flood protection.
- Recreation.
- Drinking water extraction.
- Creation of land for habitation and agriculture

[3] Article 4.3 (b) WFD. *"Member States may designate [...] as heavily modified, when: (b) the beneficial objectives served by the [...] modified characteristics of the water body can not, for reasons of technical feasibility or disproportionate costs, reasonably be achieved by other means, which are a significantly better environmental option."*

7.3.2 Alternatives to the existing "water use"

Alternatives can be distinguished at different levels:

- Displacement of a use from one waterbody or catchment to another. However, this alternative leads often to a displacement of the problem as the water uses, such as recreation, shippery, fishery, mineral extraction or agriculture, will cause negative impacts there. Thus, this is in many cases not really a good alternative.
- Performing use in an alternative way: drinking water can be extracted from surface water instead of ground water. Goods can be transported on the road or rail instead of on the water.
- Adaptation of uses: the use can be performed in an ecologically better way, such as biological farming for the agricultural function.

For the impacted uses we bring up the following alternatives and discuss their technical feasibility and costs.

1. Significant impact: Inundation of polders

- Flevopolder: There is no alternative space for the Flevopolder and its habitation and agriculture, as the population pressure in the Netherlands is very high and the demand for space of the different functions exceeds largely the available amount of space (Fifth National report on Spatial Planning). This means that inundation of a part of the polder is technically and societally not feasible.
- Horstermeerpolder: Verstraelen et al. (1992) estimated the costs of the total inundation of the Horstermeerpolder (600 ha) to be 9,24 million €/year on the basis of the costs of buying agricultural and built land. Inundation of 75% of the area, excluding the built up area would require an annual investment of 2,7 million € for 30 years. Total inundation is consered to be unrealistic because of the costs and the public resistance. However, a step by step realization of 75% inundation might still be a future option to restore the former groundwater hydrology of the area and rehabilitate the regional shallow lakes as Lake Loosdrecht and the Vechtplassen (Verstraelen et al., 1992).
- Bethunepolder: The Bethune polder is 540 ha and has ±200 inhabitants (pers.comm. Gemeente Maarssen). No study has been found on the costs of inundating the Bethunepolder. We presume that the costs of buying the agricultural and built land will be in the same range as the costs for the Horstermeerpolder. Moreover, the Bethunepolder is presently used for drinking water extraction (See next section).

2. Significant impact: Stopping or reducing the drinking water extraction

The drinking water extraction in the Bethunepolder or the Gooi hill ridge could be replaced by alternative drinking water sources, such as using surface water.

With regard to the extraction at the Gooi hill ridge the groundwater management plan of the Province of North-Holland aims at a 50% reduction of the extraction of groundwater from the northern part of the Gooi hill ridge within 10 years to reduce the negative ecological effects of the extraction. The province Utrecht aims also at a future reduction of groundwater extraction (Province Utrecht, Waterhuishoudingsplan 1999-2003). The local drinking water company (Waterleidingbedrijf Midden Nederland) plans to reduce groundwater extraction with a volume of 9 million m^3 water in the area eastern of the Amsterdam Rhine canal. However, the use of surface water as source for drinking water is more expensive due to higher purification costs and has a higher risk of pollution in the drinking water. Therefore, a large scale switch from groundwater to surface water is not possible yet.

For the Bethunepolder extraction an environmental impact assessment (W+B, 1997) concluded that replacing the extraction of seepage water from the Bethune polder by extraction of surface water from the Amsterdam-Rijn canal was not a serious alternative, because:

- The salt concentration of the Amsterdam-Rijn canal (±150 mg/l Cl^-) is much higher than the values of the water from the Bethunepolder (±50 mg/l Cl^-). The salt concentration may not exceed 80mg/l Cl^-. This means that for purification hyperfiltration has to be applied to 50% of the extracted water. This hyperfiltration leads to very high costs, because 1) the waste water has to be transported and discharged into the North Sea and 2) the technique leads to a high use of energy and chemicals. Moreover, the quality of the drinking water will be more unhealthy than the groundwater from the Bethunepolder.
- The risk of a deficiency of drinking water due to pollution of the surface water (e.g. result of industrial or transport accident) is higher than when groundwater is used. The risk can be lowered by creating a larger drinking water reservoir, which can be as drinking water source during these calamities. The creation of this drinking water reservoir means that either neighboring lakes have to be changed into such a reservoir leading to losses of ecological values or land has to be inundated leading probably to high costs.

3. Significant impact: Removal of recreational facilities

Displacement of the 29 yacht-bassins and ±8000 yachts of Loosdrecht to another lake is not a real alternative, as the yacht-bassins will have the same negative effect on the other lake as in Loosdrecht.

The present recreation could be adapted, for example the recreational yachts could have a shallower bottom to reduce the disturbance caused by sailing. Landing sites and yacht-basins can be adapted to enable more natural banks. Recreation can be limited at certain locations and at certain times. These alternatives, their feasibility and costs have not yet been studied for Lake Loosdrecht. However, as recreation is the main function of Lake Loosdrecht, the costs could be high.

7.4 Designation of Heavily Modified Water Bodies

[Describe how the designation process has been applied (include maps of designated water bodies). See HMW paper 3 ver 3, paper 7 ver 2.

What issues have determined the scope of the designation - compare different approaches (see HMW paper 7 ver 2). It is recommended that both designation options described in paper 7 ver 2 fig.7 & 8 are applied. This involves:

1. the case where only the morphology of the water body is altered and it affects the ecological status or
2. the case where the hydromorphology is altered and it affects the ecological status.

The preferred options should then be identified.]

On the basis of the information described in paragraph 7.2 and 7.3 Lake Loosdrecht is designated as Heavily Modified Water. There were no alternatives for the serious impacts or the costs of the alternatives were too high.

With regard to the two approaches which have to be applied (see HMW paper 7 ver 2), it is concluded that in Lake Loosdrecht both the morphology and the hydrology have been altered, leading to the status of HMW.

7.5 Discussion and Conclusions

[Discuss lessons learned, any problems encountered and how they were overcome.]

Definition of a natural water body

This discussion point relates to the question if a water body is designated as natural based on the state of the biological parameters or based on a natural hydrological, morphological and ecological functioning. This question is relevant as many Dutch lakes have suffered from eutrophication. Oligotrophication of eutrophicated shallow lakes leads to a hysteresis effect, meaning that there are different threshold nutrient loadings for transitions between the clear and turbid equilibrium state: the nutrient loading has to be lower, if the lake is in an turbid, eutrophic state and has to switch to a clear, mesotrophic state than the nutrient loading, which causes the switch from clear to turbid. The hysteresis effect implies for the watermanagement that the nutrient concentrations have to be lower than the concentrations in a clear state prior to the switch to a turbid state. This is for many lakes a difficult task, as population densities and agricultural use in the catchment have multiplied since the 19th century. In order to reach a clear, mesotrophic lake numerous restoration measures have been taken, such as flushing with nutrient-poor seepage water, biomanipulation, digging of a silt catch in the bottom of the lake, dephosporization of the inlet water. These measures have been applied with different degrees of succes in the Netherlands, which shows that the equilibrium of most clear lakes is still unstable and depends on a number of artificial and sophisticated measures. Moreover, the hydromorphology of these lakes has often been changed drastically. For example, in Lake Loosdrecht part of the inlet water is chemically depleted from phosphor. The question is if such systems can really be called natural waters, even if the biological and physico-chemical parameters have reached the good ecological status (as stated by the designation scheme of in the Terms of Reference). We recommend that a natural hydromorphological functioning should also be a criterium to designate a water as natural.

Alternatives for water uses

The question is what type of alternative should be described and at what scale should the alternatives be derived? We distinguish the following types:

- Displacement of uses from one lake to another: if uses, such as recreation, shippery, fishery, mineral extraction or agriculture, are moved to another lake or catchment this will lead to negative impacts there. Thus, this is in many cases not really a good alternative.
- Performing use in an alternative way: drinking water can be extracted from surface water instead of ground water. Goods can be transported on the road or rail instead of on the water. This type of alternative can be reasonable for many uses.

- Adaptation of uses: agriculture can be performed in an ecologically better way (biological farming), recreational yachts can be adapted by having an undeeper underside. Landing sites and yacht-basins can be adapted to more natural water levels. Recreation can be limited at certain locations and at certain times. This type of alternative can be reasonable for many uses.

We think that determining the costs for all negative impacts on uses of all water bodies in the Netherlands will be an enormous task. The question if it is necessary to describe all possible alternatives (and their costs and feasibility) in case one alternative has been identified, which is not technically feasible.

In Lake Loosdrecht case study, many data are costs of alternatives are not available, as no relevant studies have been performed. This complicates the designation of a water body as Heavily modified. In the Netherlands, an environmental impact assessment is obligatory for certain new activities. However, the EIA assesses the most environmental friendly way of performing or realising the activity, but not so much the need for that activity as such (balancing the economic and environmental costs and benefits of the activity).

Calculation of costs

How detailed should the costs of alternatives be calculated? Is it sufficient to describe the characteristics of the use in certain cases. In Lake Loosdrecht part of the Flevopolder should be inundated as hydromorphological measure to reach the GES. The Flevopolder is a large polder of 241.200 ha with 328.767 inhabitants in 6 municipalities. Inundation of a part of this polder will obviously lead to disproportionate costs. Have these costs really to be calculated for the designation of HMW or it is sufficient to describe the characteristics of the polder and its economic functions?

8 Definition of Maximum Ecological Potential (6 pages)

[Please discuss, to the extent possible at this stage, the maximum ecological potential (MEP) of the water body that is achievable (see WFD Annex II, 1.3 "Establishment of Type-Specific Reference Conditions for Surface Water Body Types", with reference to WFD Annex V, Table 1.2.5 "Definitions for Maximum, Good and Moderate Ecological Potential for Heavily Modified or Artificial Water Bodies" giving the normative definitions of ecological potential). Identify any areas requiring further clarification.]

8.1 Determining Maximum Ecological Potential

The HMW designation shows that a return to the oligotrophic reference phase is not possible for Lake Loosdrecht. Therefore, the Maximum Ecological Potential will be based on phase 2 in the history of Lake Loosdrecht: the clear, mesotrophic lake dominated by macrophytes. The MEP will be described on the basis of historical data from phase 2 (1930-1955) in the history of Lake Loosdrecht (see Box 3). This phase is the period after the oligotrophic phase, which is the reference condition of the lake and it is the phase before the eutrophication of the lake into a turbid, cyanobacteria dominated situation. The values of the biological and physico-chemical parameters during phase 2 are derived from the AMOEBE Loosdrecht (Hofstra & Van Liere, 1992). The AMOEBE is an ecological assessment instrument, which describes the ecological objective of Lake Loosdrecht (see table 8.1). The desired values presented in table 8.1 are not based on measurements, but have been estimated on the basis of historical information on biological elements.

Table 8.1 AMOEBE values of the biological and physico-chemical parameters during phase 2 of the history of Lake Loosdrecht, which is also the MEP (Hofstra & Van Liere, 1992)

Parameter	Present value (1990)	Desired value
Abiotic		
Transparency (yearly average, m)	0,4	1,9
Total P (yearly average, mgP/l)	0,1	0,0054
Soluble reactive P (yearly average, mgP/l)	0,002	0,0015
Mineral nitrogen (summer average, mgN/l)	0,840	0,238
Salinity (summer average, mg/l)	305	231
Oxygen (summer average, mgO_2/l)	10,4	11,0
Plankton		
Total zooplankton (carbon, mgC/l)	0,575	0,075
Total cyanobacteria (fresh weight, mg/l)	30,6	1,25
Total diatoms (fresh weight, mg/l)	0,81	0,06
Total green algae (fresh weight, mg/l)	0	0,48
Chlorophyll a (mg/l)	0,1	0,025
Vegetation		total covering according to Tansley (1946)
Characeae-group (4 species)	0	15
Potamegoton-group (10 species)	1	11
Menyanthes-group (7 species)	2	14
Thelypteris-group (15 species)	6	25
Nymphaea- group (7 species)	14	18
Butomus-group (6 species)	11	15
Caltha-group (10 species)	14	24

Parameter	Present value (1990)	Desired value
Fish		
Pike (fresh weight, kg/ha)	1	45
Bream (fresh weight, kg/ha)	180	50
Surroundings of lake		
Presence of helophytes and marsh vegetation	Absent due to fixed banks	Presence due to the existence of natural banks and marshes

8.2 Measures for Achieving MEP

[Description of measures that would theoretically have to be undertaken in order to allow comparison with the closest comparable water body.

How has the appropriate level of mitigation been defined?]

At present the lake is still turbid and eutrophic (phase 4 in history, see Box 3). The measures aim to bring about the switch from a turbid to a clear lake. For this switch two different paths are needed:

1. The P load into the lake has to be reduced.
2. The turbidity caused by the resuspended silt has to be decreased.

Ad 1) Possible measures to reduce the P load into Loosdrecht are:

- Reducing the external loading via the inlet of allochtonous water via removing the phosphate in the water in a chemical way (dephosporization) or by reducing the inlet of the relatively phosphate rich seepage water from the Bethune polder.
- Reducing the external loading via diffuse emissions of agriculture, recreation and spill-overs in the catchment.
- Reducing the internal loading by biomanipulation. Removal of a large fish biomass will reduce the amount of nutrients in Lake Loosdrecht.

Ad 2) Measure to decrease the turbidity caused by the resuspended silt:

Creation of a silt catch by digging of 4 holes of ±15 m deep in 10% surface of the lake. To implement this measure an environmental impact assessment has been carried out.

Next to restoring the clear state of the water body, the banks of the lake should have a higher ecological value by creating natural banks and marshes. Measures needed are the removal of bank fixations, the planning and maintenance of the natural banks and marshes.

8.3 Comparison with Comparable Water Body

[Describe how a comparable water body was identified - what selection strategy was defined based upon typological (physico-chemical and hydromorphological) parameters. Was biological data used as part of the selection process?

Was the ecological condition of the water body comparable to the HMWB?]

Spatial reference lakes, which are clear and dominated by submerged macrophytes are the Naardermeer and the Stichtse Ankeveense plassen. Both lakes are situated in the same region as Lake Loosdrecht.

8.4 Discussion and Conclusions

[Discuss lessons learned, any problems encountered and how they were overcome.]

Ecological effect of restoration measure is uncertain

The ecological effect of the silt catch, which aims to decrease the turbidity caused by the resuspended silt, is uncertain. This measure has never carried out before and there is a risk that the ecological condition will decrease due to the loss of potential surface for macrophyte growth and the occurence of mycocystis blooms in the deep holes.

Negative effects of MEP on present functions

The MEP is based on a clear water lake with macrophytes. This reference will have negative effects on some present functions:

- a large biomass of waterplants will hamper the water recreation, as the plants could obstruct the sailing with yachts;
- a turbid, eutrophicated lake has a large biomass of fish. The measures to reduce the nutrient loading will also reduce the fish biomass, which impacts the commercial fisheries.

9 Definition of Good Ecological Potential (6 pages)

9.1 Determination of Good Ecological Potential

[Describe the ecological potential to be achieved in the medium and long term. Refer to paper 3 ver 3, nr.3.

How has slight deviation from the MEP been defined?

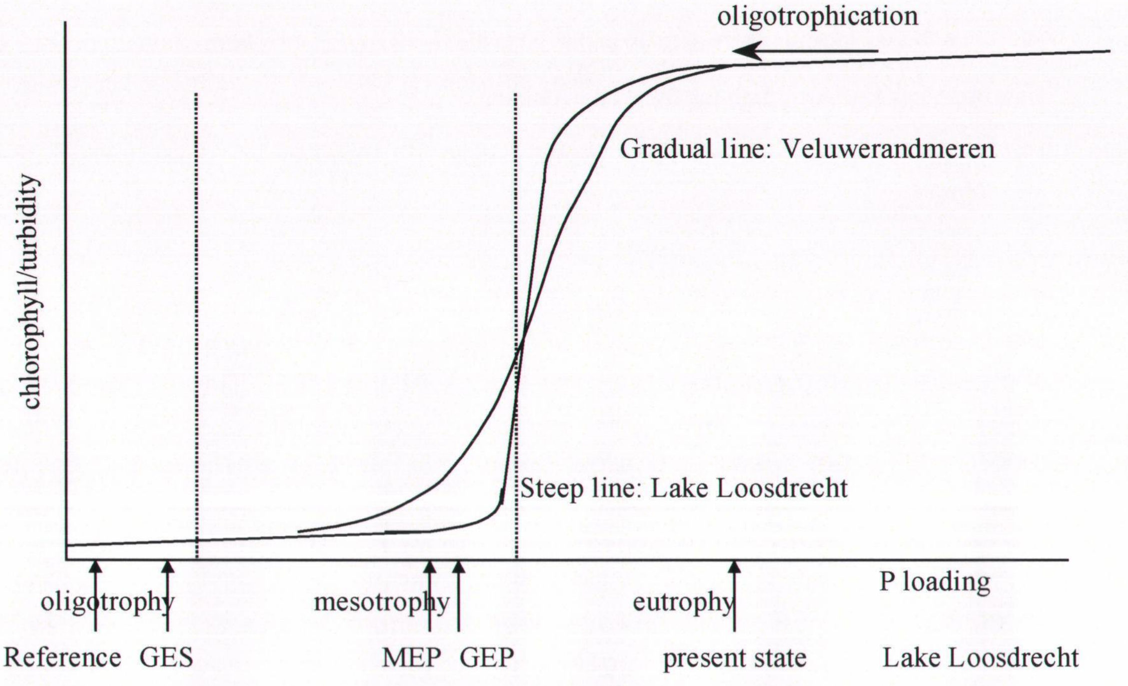
Has the definition of good ecological potential been influenced by the practicability of the mitigation measures?]

The GEP is defined as a slight deviation from the MEP, which means that the values of the biological, hydromorphological and physico-chemical parameters of the GEP are somewhat lower (or higher) than the values of the MEP. This is however difficult to implement to shallow lakes. The relation between abiotic parameters and ecological functioning is not linear in shallow lakes, but has two equilibrium states (clear and turbid), which can switch depending on the nutrient loading, restoration measures, the area of macrophytes and helophytes etc. The MEP, described in table 8.1, will probably lead to a clear state of Lake Loosdrecht. Abiotic values, which are somewhat higher or lower than the MEP could however lead to a turbid state of the lake, in which the biological parameters deviate largely from the MEP. The acceptable difference between MEP and GEP depends per lake and has to be studied more in detail (see explanation in Box 4). Therefore, we decided to define the same values of the biological, hydromorphological and physico-chemical parameters for the MEP and the GEP. The only difference between MEP and GEP will be the state of the banks. The MEP includes the development of natural banks and marshes. In the GEP the embankments remain in the present state. This definition has been influenced by the practicability of the mitigation measures: the removal of natural banks has a negative impact on the recreation function, which is the main use of the lake.

Box 4. The equilibrium between meso- and eutrophic

As explained in Box 2 the difference in threshold nutrient loading between a clear, mesotrophic and a turbid, eutrophic lake depends on the lake characteristics and the application of restoration measures. Also the form of the switch from turbid to clear and the related nutrient loading differs per lake and depends among others on the existence of a seed bank. A seed bank allows a quicker restoration of the macrophyte growth and a quicker switch from turbid to clear in case the threshold nutrient loading has been reached. In other words, the steepness of the line, representing the switch of equilibrium can be higher or lower. The steepness of the line defines the acceptable difference in nutrient loading between the GEP and MEP. If the steepness is lower, the relation between turbidity and nutrient loading has a more linear character and the difference between GEP and MEP can be higher than with a very steep line. In figure 9.1 the "switch lines" are represented for Lake Loosdrecht and the Veluwerandmeren. The steepness of the switch line of Lake Loosdrecht is higher than the Veluwerandmeren, because Lake Loosdrecht has still the seed bank of the mesotrophic phase, whereas the Veluwerandmeren had no seed bank due to its origin as estuary.

Figure 9.1 Relation between nutrient loading and turbidity/chlorophyll. The reference condition, GES, GEP and MEP of Lake Loosdrecht are also represented



9.2 Identification of Measures for Protecting and Enhancing the Ecological Quality

[In this chapter, please describe the options for measures designed to protect and if necessary enhance the ecological quality of the water body. WFD Article 11 requires the establishment of a programme of measures, distinguishing between basic and supplementary measures.]

The measures for achieving the GEP are the same as those for the MEP except for the restoration of the banks:

- Measure to decrease the turbidity caused by the resuspended silt: Creation of a silt catch by digging of 4 holes of ±15 m deep in 10% surface of the lake. To implement this measure an environmental impact assessment has to be carried out.
- Possible measures to reduce the P load into Loosdrecht are:
  - reducing the external loading via the inlet of allochtonous water via removing the phosphate in the water in a chemical way (dephosporization) or by reducing the inlet of the relatively phosphate rich seepage water from the Bethune polder;
  - reducing the external loading via diffuse emissions of agriculture, recreation and spill-overs in the catchment;
  - reducing the internal loading by biomanipulation. Removal of a large fish biomass will reduce the amount of nutrients in Lake Loosdrecht.

9.2.1 Basic Measures

[See Art. 11.3, which also refers to Art.10 and part A of Annex VI.

How has the link between the good ecological potential and any possible measures been determined?]

9.2.2 Supplementary Measures

[See Art. 11.4 and part B of Annex VI.

Can supplementary measures contribute to delivering environmental improvement?]

9.3 Discussion and Conclusions

[Discuss lessons learned, any problems encountered and how they were overcome.]

Definition of GEP on the basis of MEP

According to its definition the GEP should deviate slightly from the MEP, which means that the values of the biological, hydromorphological and physico-chemical parameters of the GEP are somewhat lower (or higher) than the values of the MEP. This is however difficult to implement to shallow lakes. The relation between abiotic parameters and ecological functioning of shallow lakes is not linear, but shows two equilibrium states (clear and turbid), which can switch depending on the nutrient loading, restoration measures, the area of macrophytes and helophytes etc. The MEP leads to a clear equilibrium in the Veluwerandmeren. Abiotic values, which are somewhat higher or lower than the MEP could however lead to a turbid state of the lake, in which the biological parameters deviate largely from the MEP. The acceptable difference between MEP and GEP depends per lake and has to be studied more in detail. Therefore, it has been decided for both cases on Dutch lakes to define for the GEP the same values as for the MEP for the parameters applying to the water body. The difference between MEP and GEP is the ecological condition of the banks; in the MEP the banks are natural, whereas in the GEP they remain fixed.

Difference between basic and supplementary measures

The abovementioned measures have not been distinguished as basic and supplementary measures, as the difference between the two types of measures is unclear. Comparison of the definition of both type of measures in the Water Framework Directive in article 11, part 3 and 4, revealed no clear difference, as:

- they both aim to achieve the ecological objectives described in article 4;
- the definition of the basic measure (article 11, part 3) focuses on the objective of a measure. The definition of the supplementary measure (article 11, part 4) describes the instruments to be used in a non-exclusive list of supplementary measures in Annex VI, part B. As all possible types of instruments (legislative, economic etc.) are listed all possible measures will fall under one of the instruments.

Application of time derogation for lakes

The ecological effect of restoration measures in lakes takes often a long time. The reason can be the high retention time of certain lakes or the hysteresis effect due to the internal loading of the lakes from the sediment. Possibly the time derogation will be needed (Article 4, part 4) stating that deadlines may be extended, because the natural conditions do not allow a timely improvement in the status of the water body.

PART III

10 Conclusions, Options and Recommendations (5 pages)

10.1 Conclusions

[Highlight the "lessons learned" concerning the treatment of heavily modified water bodies in the Water Framework Directive. Discuss applicability of results in other river basins in the same ecoregion (of your country).]

10.2 Options and Recommendations

[Recommendations should be of general nature and pertain to the objectives of the European project on heavily modified water bodies. In particular, items for consideration in the harmonised and consistent implementation of the Water Framework Directive should be discussed. Highlight any clarifications of Annexes or guidelines that may be needed or helpful.]

10.3 Discussion points of the Dutch HMW case Lake Loosdrecht

The lessons learned and the recommendations have been combined in a number of discussion points. Some of these points do not relate only to the lake in this case study Lake Loosdrecht, but apply also to the other Dutch cases on the Veluwerandmeren or on shallow lakes in the Netherlands in general.

1. Difference between artificial and heavily modified

Numerous lakes in the Netherlands are created due to large human influence. The difference between an artifical or a heavily modified water is therefore not always clear. With regard to Lake Loosdrecht, the preconditions for the creation of lake have been made by industrial peatmining. Subsequent wind and wave action eroded the rest of the peatbanks and a system of shallow, interconnected lakes developed. We defined the difference between artificial and heavily modified in the following way:

- In case the water has been dug by humans, the waterbody is artificial (e.g. canals, pools for swimming, pools resulting from mineral extraction). The question remains then to what extent the water body has to be dug to be artificial (partially or completely).
- In case human activity has made the preconditions for creation, but the water body has not dug by humans, the waterbody is heavily modified.

If the criterium of digging of the waterbody still does not lead to a clear difference, a second criterium will be applied: the existance of a natural reference condition on the basis of a comparable waterbody. If a natural reference condition applies to that water body, it is HMW. In case there exists no natural reference condition for that water body, as it differs too much from natural waters, the water is artificial. On the basis of these two criteria, Lake Loosdrecht is designated Heavily modified instead of artificial.

We would appreciate if the future guidance will provide clear criteria for determining the difference between artificial and heavily modified.

2. Selection of reference condition

The selection of the reference condition is a crucial step in the HMW designation, as it determines how much the present ecological status differs from the good ecological status. If this difference is very small, the water body should be designated natural.

The reference condition is defined as the undisturbed condition of an ecological type of a certain water category. This definition means that the reference condition should not be defined for an individual waterbody, but for an ecological type. Inside an ecoregion more water bodies of that ecological type should exist. In case former hydromorphological changes have led to a change of water category (change from estuary to fresh water lake due to building of dam), the reference condition should be based on the new water category (undisturbed freshwater lake). This means that the reference condition is not based on an undisturbed historical situation, but on a spatial or theoretical based reference.

However, if the present policy aims to "remove" the former hydromorphological changes and to restore the former water category, then the reference condition should be based on the former water category and the reference condition can be historically based (e.g. the reference condition of the present lake Haringvliet is an estuary, as it has already been decided that the Haringvliet dam will be opened in the future).

Application of this definition of the reference condition on lakes in the Netherlands leads to the following observations:

- A. Many lakes have different phases in history with a different level of hydromorphological impact and a different ecological condition of even a different water category. Therefore, it is not always very clear which phase is the undisturbed reference condition. The selection of a certain phase as reference condition has consequences for the designation as natural or HMW. This is examplified by Lake Loosdrecht :
    - selection of oligotrophic condition in ±1920 as reference condition, means that the lake in its present condition can not reach the GES and is designated as HMW;

- selection of the mesotrophic condition in the period 1930-1955 as reference condition, means that the lake is near the GES before 2015 (applies only to the water body, not to the banks). The mesotrophic condition is the result of eutrophication of the inlet water and drinking water extraction, therefore this condition is not undisturbed and will not be selected as reference.

- B. The ecological functioning of shallow freshwater lakes is the product of its hydromorphological environment. Especially in an undisturbed state (when the human impact such as eutrophication has been removed) the hydrology, morphology and ecology of each lake is very specific. For example, the oligotrophic reference condition of Lake Loosdrecht is the result of the creation of the lakes at that specific location as a result of human influence. A natural lake would never have been formed there. Therefore, it will be difficult to define a reference condition, that applies to a number of lakes. The risk is that either the reference condtion is too detailed and differs too much from the "real" undisturbed condition of a lake or the description of the reference is too general and is not suitable for ecological assessment of the lake.

3. Effect of designation as HMW or natural on the present uses of the waterbody

Lake Loosdrecht is important for recreation and has a number of additional uses, such as fishery and water extraction. The societal acceptance of limitations imposed upon these uses is low, as these functions provide employment and income in the region. The question is to what extent the designation as natural or HMW affects present uses of the waterbodies? The WFD states that a deterioration of the ecological status is not allowed and the MEP should represent the maximum ecological potential of the water. Uses can only profit from the designation in case the uses take advantage from the hydromorphological changes leading to the designation. Certain uses, such as fishery, have no or do not profit from the hydromorphological impacts. The designation as HMW or natural should make no difference for that use. Other uses, such as recreation, profit from fixed banks and a fixed water level, such as in Lake Loosdrecht and take advantage from the designation as HMW.

4. Selection of the correct scale of waterbodies

The selection of the correct scale of waterbodies is unclear. In the Lake Loosdrecht area there are a number of connected or neighboring lakes, which have a comparable hydrology and pressures and impacts, but the ecology is not completely identical in the different lakes. The question is if the lakes should be selected as different water bodies or as one water body.

5. Definition of a natural water body

This discussion point relates to the question if a water body is designated as natural based on the state of the biological parameters or based on a natural hydrological, morphological and ecological functioning. This question is relevant as many Dutch lakes have suffered from eutrophication. Oligotrophication of eutrophicated shallow lakes leads to a hysteresis effect, meaning that there are different threshold nutrient loadings for transitions between the clear and turbid equilibrium state: the nutrient loading has to be lower, if the lake is in an turbid, eutrophic state and has to switch to a clear, mesotrophic state than the nutrient loading, which causes the switch from clear to turbid. The hysteresis effect implies for the watermanagement that the nutrient concentrations have to be lower than the concentrations in a clear state prior to the switch to a turbid state. This is for many lakes a difficult task, as population densities and agricultural use in the catchment have multiplied since the 19th century. In order to reach a clear, mesotrophic lake numerous restoration measures have been taken, such as flushing with nutrient-poor seepage water, biomanipulation, digging of a silt catch in the bottom of the lake, dephosporization of the inlet water. These measures have been applied with different degrees of succes in the Netherlands, which shows that the equilibrium of most clear lakes is still unstable and depends on a number of artificial and sophisticated measures. Moreover, the hydromorphology of these lakes has often been changed drastically. For example, in Lake Loosdrecht part of the inlet water is chemically depleted from phosphor. The question is if such systems can really be called natural waters, even if the biological and physico-chemical parameters have reached the good ecological status (as stated by the designation scheme of in the Terms of Reference). We recommend that a natural hydromorphological functioning should also be a criterium to designate a water as natural.

6. Application of time derogation for lakes

The ecological effect of restoration measures in lakes takes often a long time. The reason can be the high retention time of certain lakes or the hysteresis effect due to the internal loading of the lakes from the sediment. Possibly the time derogation will be needed (Article 4, part 4) stating that deadlines may be extended, because the natural conditions do not allow a timely improvement in the status of the water body.

7. Effect of ground water hydrology on ecology lakes

Both cases on lakes show that the ecological condition of the lakes has changed due to changes in the groundwater hydrology leading to different patterns of seepage and infiltration. These changes in groundwater hydrology can be caused by alterations outside the catchment. For example, the reclamation of the Flevopolder, lying outside the catchment of Lake Loosdrecht, has affected the seepage stream into Lake Loosdrecht and the Veluwelakes. This observation has the following consequences:

- The measures needed to restore the former groundwater hydrology pattern have to be taken outside the catchment of the river basin management plan (borders are based on surface water hydrology). The water managers of the lake have present in most cases no authority to take measures in the area outside the catchment. However, the WFD states that measures in a catchment may not have a negative impact on other catchments.

- Groundwater measures should not only to be assessed on their impact on the groundwater quantity and quality, but also on their impact on the surface water bodies.
- Certain historic changes are irreparable, as original groundwater flows and –quality have been changed and can not come back in their original form. Therefore, it is uncertain if the inundation of the polders will repair the former groundwater flows.

8. Alternatives for water uses

The question is what type of alternative should be described and at what scale should the alternatives be derived? We distinguish the following types:

- Displacement of uses from one lake to another: if uses, such as recreation, shippery, fishery, mineral extraction or agriculture, are moved to another lake or catchment this will lead to negative impacts there. Thus, this is in many cases not really a good alternative.
- Performing use in an alternative way: drinking water can be extracted from surface water instead of ground water. Goods can be transported on the road or rail instead of on the water. This type of alternative can be reasonable for many uses.
- Adaptation of uses: agriculture can be performed in an ecologically better way (biological farming), recreational yachts can be adapted by having an undeeper underside. Landing sites and yacht-basins can be adapted to more natural water levels. Recreation can be limited at certain locations and at certain times. This type of alternative can be reasonable for many uses.

We think that determining the costs for all negative impacts on uses of all water bodies in the Netherlands will be an enormous task. In the case study many data are costs of alternatives are not available, as no relevant studies have been performed. In the Netherlands, an environmental impact assessment is obligatory for certain new activities. However, the EIA assesses the most environmental friendly way of performing or realizing the activity, but not so much the need for that activity as such (balancing the economic and environmental costs and benefits of the activity).

9. Calculation of costs

How detailed should the costs of alternatives be calculated? Or is it sufficient to describe the characteristics of the use in certain cases. In the Lake Loosdrecht case a hydromorphological measure to reach the GES is to partly inundate the Flevopolder. The Flevopolder is a large polder of 241.200 ha with 328.767 inhabitants in 6 municipalities. Inundation of a part of this polder will obviously lead to disproportionate costs. However, have these costs really to be calculated for the designation of HMW or it is suficient to describe the characteristics of the polder and its economic functions.

10. Definition of GEP on the basis of MEP

According to its definition the GEP should deviate slightly from the MEP, which means that the values of the biological, hydromorphological and physico-chemical parameters of the GEP are somewhat lower (or higher) than the values of the MEP. This is however difficult to implement to shallow lakes. The relation between abiotic parameters and ecological functioning of shallow lakes is not linear, but shows two equilibrium states (clear and turbid), which can switch depending on the nutrient loading, restoration measures, the area of macrophytes and helophytes etc. The MEP leads to a clear equilibrium in the Veluwerandmeren. Abiotic values, which are somewhat higher or lower than the MEP could however lead to a turbid state of the lake, in which the biological parameters deviate largely from the MEP. The acceptable difference between MEP and GEP depends per lake and has to be studied more in detail. Therefore, it has been decided for both cases on Dutch lakes to define for the GEP the same values as for the MEP for the parameters applying to the water body. The difference between MEP and GEP is the ecological condition of the banks; in the MEP the banks are natural, whereas in the GEP they remain fixed.

11. Difference between basic and supplementary measures

The measures to achieve the GEP have not been distinguished as basic and supplementary measures, as the difference between the two types of measures is unclear. Comparison of the definition of both type of measures in the Water Framework Directive in article 11, part 3 and 4, revealed no clear difference, as:

- They both aim to achieve the ecological objectives described in article 4.
- The definition of the basic measure (article 11, part 3) focuses on the objective of a measure. The definition of the supplementary measure (article 11, part 4) describes the instruments to be used in a non-exclusive list of supplementary measures in Annex VI, part B. As all possible types of instruments (legislative, economic etc.) are listed, all possible measures will fall under one of the instruments.

We would recommend providing clearer definitions and criteria for both type of measures.

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