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A Cost-effective Strategy for Pollution Abatement in the Hernad Catchment, Hungary

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Abstract: The overall aims of this study are to elaborate tools for a more cost-effective and recipient oriented water management, and to conduct a specific abatement analysis in the Hernad catchment area.

The Hernad river is transboundary. It has its source in Slovakia, and enters Hungary in the north -eastern part of the country. 19% of the catchment area is in Hungary, of which crop area is predominant. Five different water quality objectives have been proposed, based on user interests and general water quality criteria. Nitrogen inputs, especially ammonia, are the most important inputs to be reduced. This implies also a reduction of BOD. Reduction of phosphorus is important if the drinking water quality should be achieved throughout the river. The most important measures to be implemented in the municipal sector is building of wastewater treatment plants for 23 of the most important municipalities ("hot-spots"), which will reduce BOD, nitrogen and phosphorus inputs. Agricultural measures include better manure handling, spring tillage of the soil and better utilisation of manure.

The objectives will only partly be met by implementing measures on the Hungarian side. Measures must also be implemented on the Slovakian side to meet the user requirements, and to secure a cost-effective approach through the entire catchment area.

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For the Administration

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A Cost-effective Strategy for Pollution Abatement in the Hernád Catchment, Hungary

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Preface

The Governments of Hungary and Norway have signed a bilateral environmental protection agreement. As part of the agreement this collaborative project has been carried out.

This study "A cost-effective strategy for pollution abatement in the Hernád Catchment, Hungary" has been a co-operation project between the Norwegian Institute for Water Research (NIVA) and the Water Resources Research Centre Plc.(VITUKI).

The project is aimed at solving local water quality problems in the Hungarian part of the Hernád River catchment, within the framework of today's central and regional water management system. A cost-efficient abatement programme has been prepared to give a significant contribution to restore the ecological balance and to meet the user requirements for the surface waters. As part of the project there has been two missions. The first mission was when János Fehér from the VITUKI, came to Oslo (NIVA) tot discuss the framework of the study. The second mission was when the authors of this report went to Budapest to discuss the project in more detail with representatives from the VITUKI. Combined with an Excursion trip to the Hernád Region, we also had meetings with several regional Authorities in Miskolc, i.e. the Water Authorities, the Environment Inspectorate and the Soil Protection Agency.

The study has been financed by the Norwegian State Pollution Control Authority (SFT), and the project team would like to thank Bjørg Storesund and Nina Markussen in SFT for their contribution. This report has been prepared by Research Manager Jon Lasse Bratli (Project leader) and Research Scientist Kjersti Dagestad. Technical Assistant Luis Benavides has contributed in data processing and presentation, while Josef Kotai has translated written material from Hungarian into Norwegian. Stig A. Borgvang has read through the manuscript and given comments of great value..

Finally a special thank to our Hungarian co-workers János Fehér, Beáta Pataki and István Galambos who have showed great enthusiasm and assisted us with much valuable information, professional advice and put much personal efforts into providing the necessary data for this report. We hope that the study can contribute to identify and solve some of the water quality problems in the region.

Oslo, 24. April, 1996

Jon Lasse Bratli

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Summary

This project is part of the bi-lateral co-operation between Hungary (represented by VITUKI) and Norway (represented by NIVA). The overall aims of the study is to develop tools for the elaboration of an optimal cost-effective strategy for pollution abatement, and to conduct a specific abatement analysis in the Hernád watershed, where these tools are used.

The severe pollution problems in Hungary, combined with a weak national economy calls for this kind of cost-effective solutions. The aim is to achieve a water quality that meet requirements of the water users, both the commercial user interests and those of the public.

The VITUKI has already started to elaborate water quality objectives for selected Hungarian Watersheds. Hernád is one of the prioritised watershed and the study reported here will serve as a basis for phase 2 of this national project. In addition, this study specifies measures for major point pollution sources and diffuse pollution sources. This should lead to a more recipient oriented approach where the Water Management Authority will consider the objectives for the recipient (including the user interests), today's load and the present water quality, before implementing measures or issue permits.

The Hernád watershed is transboundary and has its source in the Slovakian Republic and enters Hungary in the north eastern part of the country. It flows southwards and meets Sajó, which flows to Tisza.

The total catchment area of the Hernád river is 5436 km^2. Only a part of it, 1013 km^2 (19%), is located in Hungary. In this part, forests cover 200 km^2 (20%) of the total catchment area and grassland 260 km^2 (26%). The crop area is predominantly tilled, and covers 410 km^2 (41%). Built up areas (roads, towns and villages), water areas, riverbanks, etc. cover 137 km^2 (13%).

Agriculture is one major activity. The main crops are winter-wheat, maize, sunflower, lucern, rape and grape, potatoes and barley. The total population in the catchment is approximately 64 000, distributed on 72 municipalities. The catchment area is divided into 3 recipient areas which today have different water use interests. Agricultural activities are a main pollution source.

The water resources management in Hungary is organised by two central ministries, "the Ministry of Transportation, Telecommunication and Water Management" and "the Ministry of Environmental Protection and Regional Policy". The first ministry organises "the National Water Authority" (NWA) and the latter "the Environmental Protection Inspectorate" (NEPI). These two central administrative agencies have 12 regional units that are catchment oriented. The main task for the District Water Authority is to issue water extraction and discharge permits. The District Environmental Inspectorate carries out the water pollution and effluent control.
Water is a public property in Hungary and every measure that interfere with the quality and quantity needs to have a permit.

A comparison of the Hungarian water quality criteria and the criteria related to use, showed that the Hungarian ones were well in accordance with the criteria systems of WHO, EU and US-EPA. The list of parameters for the user criteria is however very long, and the key parameters should be agreed upon.

Many of the parameters measured in the Hernád reach the worst water quality class (V). This is the case for nitrogen and phosphorus fractions. For the oxygen and micropollutant parameters, class III

is dominating. In general the water quality is improving downstream the Slovakian border. The fact that the downstream areas are cleaner than upstream areas are quite unusual.

Not only the water quality, but even transport values (except for nitrogen) are smaller in the lower part of the river. This means that the selfpurification processes in the river are larger than the inputs of pollutants from Hungary. For all parameters the major inputs come from the Slovakian Republic, i.e. 78 % of the phosphorus, 53% of the nitrogen and almost all the inputs of micropollutants. On the Hungarian side, the major phosphorus load comes from municipal sewage from villages, of which only 5 has a treatment plant. For Nitrogen, the agriculture is the major Hungarian polluter, with a substantial part (28%) of the total loads to the river (both Slovakian and Hungarian).

Five alternative water quality objectives is proposed for the Hernád with its three recipient areas (sub-catchments). The first and less ambitious is to meet the requirements of the today's user interests, i.e. irrigation and animal water supply for the whole Hernád and drinking water quality for the lowest part of the river (Gesztely - Mouth). The stricter objectives (2-5) are set according to meet drinking water quality for a larger part of the river (2-3), and according to the general water quality criteria (4-5), which are much more strict than the user criteria.

The need for reduction of pollution loads according to the objective 1, indicate that nitrogen, especially NH_4, has to be reduced substantially, along with the micropollutant nickel. To meet stricter objectives and comply with drinking water quality further upstream, BOD, phosphorus and cadmium, also must be reduced. Objective 4 and 5, set according to the general water quality criteria, demand large reductions of all parameters, including all the micropollutants.

Different kind of technical measures have been reviewed, both within the municipal sector (including industry) and within the agricultural sector. The measures are reviewed with regard to costs, as total annual costs (including discounted investments) and effects of reduced pollution load.

Today, only 5 waste water treatment plants (WWTP) are in operation, but they are overloaded and the efficiency of removing pollutants are therefore low. It is suggested to build municipal WWTPs for 23 municipalities regarded as "hot-spots". There could be built 7 inter-municipal WWTPs (alternative 1) or one plant of each of the 23 municipalities (alternative 2). The two alternatives have very similar effects and costs. A treatment process with BOD, nitrogen and phosphorus removal is evaluated to be the best. A system for sludge handling is also reviewed.

Within the agricultural sector, different kinds of measures both regarding point sources (manure tanks) and diffuse sources (run-off from fields) are evaluated. The present handling of the manure is an important problem and imply storage in earth tanks with large leakage to surface and sub-surface water. Many of the farmers have not got any storage facility and they are spreading the manure all year around. This involves large run-off problems. This has not only a matter of protecting the environmental, but is also a question of utilising a resource in a proper way. It is suggested to set up pre-fabricated steel-plated manure tanks with PVC lining. An alternative could be to build concrete tanks on site. This is a very cost-effective measure both for phosphorus and nitrogen (and probably also BOD).

A very large load from the agricultural sector is run-off from fields. A large part of the tillage area is susceptible to erosion because the landscape has relatively steep and long slopes. The ploughing of this area should therefore predominantly be done in spring, allowing the plant root system to stabilise the soil over the winter. The winter wheat does not supply enough stability to prevent erosion. The cost-efficiency for the whole measure (when winter-wheat is included) is, however, moderate for phosphorus and nitrogen.

Manure application should be restricted to the plants growing season. This measure requires building of manure tanks, and is very cost-efficient both for phosphorus and nitrogen.

Split application of nitrogen means that the nitrogen fertiliser is spread twice, both in spring and in the middle of the growing season. This measure has in fact a *negative* cost-efficiency, which means you earn money on implementing it.

Since there hardly is any industry on the Hungarian side of the border, measures aimed at reducing the metal concentrations in the river are not considered. The problems that partly could be solved by implementing measures on the Hungarian side of the border are connected to reduction of organic matter, particles and nutrients.

In order to satisfy today's user interests (objective 1), it is necessary to reduce ammonium, nitrite, Mn, Fe, and Ni. As mentioned, Ni and other metals must be dealt with on the Slovakian side. By reducing the nitrogen load from agriculture and municipal wastewater, the total reduction will reach about 650 tonnes/y, calculated as total N. The requirement is to reduce about 800 tonnes/y of NH_4-N at Gesztely and about 1200 tonnes/y at Hidasnémeti. This means that even if all measures considered are implemented, the requirement for abatement of nitrogen will not be met in any portion of the river. However, reduction of total-N of 650 tonnes/y together with substantial reduction of organic matter would undoubtedly decrease the concentrations of ammonia, which is the most important parameter to reduce. Reduction of loading of organic matter will also reduce the problems with high Mn and Fe content. This set of measures will cost about 450 000 forints annually. This cost includes discounted investment costs and annual operation and maintenance costs.

For objective 2, providing drinking water quality up to Vizsoly, the requirement for nitrogen is the same as for objective 1, but here there is also required an abatement of phosphorus of 367 tonnes/y at Gesztely. This is not achievable with the reviewed measures. Only some 60 tonnes/y could be reduced on the Hungarian side.

The cost-effectiveness of nitrogen is in general much better for the agricultural measures than for the municipal ones. The measures within the agricultural sector with regard to nitrogen reduction are 3-50 times cheaper than the municipal measures.

To meet the requirements for objectives 2-5 this can only be done by implementing measures on the Slovakian side. This is the case for nutrients as well as for suspended matter and heavy metals. Especially for the latter category, the reduction potential in Hungary is very small.

A strong participation from the Slovakian side is crucial not only to meet the requirements from the users and improve the ecological quality of the river, but also to secure a cost-effective approach through the entire catchment area.

Hungarian summary

RÖVID ÖSSZEFOGLALÀS.

Ez a projekt egy rèsze a Magyarország (VITUKI) ès Norvègia (NIVA) közötti együttmûködèsnek. A projekt cèlkitûzèse hogy kidolgozzunk egy "költsèg hatèkony" stratègiàt amit àltalànosan ès a Hernàd vizgyüjtô terülctèn is lehet hasznàlni.

A nagyfoku szennyezetsèg ès a nehèz gazdasàgi helyzet miatt szüksèges egy "költsèg hatèkony" megoldàs, ami biztosìtja a megfelelô vìzminôsèget, a vìzfelhasznàlòk szàmàra.

VITUKI màr elkezdte, tìz kivàlasztott vìzgyüjtô, vìzmìnôsègi cèlàllapotainak kidolgozàsàt, ahol Hernàd egyike a kiemelt vizgyüjtôknek.Ez a dolgozat adna alapot a nemzeti program màsodik fàzisàhoz.
A nemzeti program mellet kitèrünk a pontszerû ès nempontszerû szennyezôforràsokra. Remeljük hogy munkànk egy vìzgyüjtô szemlèletû irànyt ad a vìzgazdàlkodàsi hatòsàgoknak a koncepciok kialakìtàsàhoz.

Hernàd folyò vìzgyüjtô területe 5436 km^2, amibôl 1013 km^2 Magyaroprszàgon van. Nagyobb rèsze Szlovàkiàhoz tartozik. A vìzgyüjtô magyarországi rèsze következô kèpen alakul: erdô 200 km^2 (20%),
mezôsèg 260 km^2 (26 %) mezôgazdasàgilag használt terület 410 km^2 (41 %). Beèpìtett terület, ut, viz
stb. 137 km^2 (13%).

Mezôgazdasàg a fô foglalkozàsi àgazat, termèkek: tengeri, gabona, burgonya, napraforgò, szôlô, lucerna ...
Lakosàg szàma kb.: 64 000 a 72 helysègben. A vizgyûjtô hàrom rèszre oszlik amiknek a hasznàlati èrdekeltsège kûlônbôzô. A mezôgazdasàg a legnagyobb szennyezèsi tènyezô.

A vìzgazdàlkodàs Magyarországon kèt minisztèriumhoz tartozik. Az egyik a Kölekedèsi ès Vìzügyi a màsik a Környezetvèdelmi ès Területfejlesztèsi Minisztèrium. Az elsôhöz tartozik az NWA a màsodikhoz a NEPI. A kèt központi szervezetnek van 12 rèszlege a vìzgyûjtôk szerinti felosztàsba.
Magyarorszàgon a vìz tàrsadalmi tulajdon, igy mindenhez ami a vizminôsèget befolyàsolja engedèly szüksèges.

A magyar vìz minôsègi kritèriumok, szabvànyok jòl megegyeznek a WHO, EU ès a US-EPA szabvànyokkal, kritèriumokkal.

Hernàd vìzminôsège sok paramèter esetèben az V-dik osztàlyba tartozik, ami a legrosszabb. Ez a helyzet a nitrogèn ès foszfor esetèben. Az oxigèn ès mikroszennyezèsek leginkàbb a III-dik osztàba vannak.
A vìzminôsèg àltalàban a szlovàk hatàrnàl a legrosszabb. A helyzet az hogy a folyò felsô rèsze szennyezettebb mint az alsò ami elèg különleges.

Nemcsak a vìz minôsèg de szàllìtàsi èrtèkek (kivève a nitrogènt) is kissebbek az alsò rèszen, ami azt jelenti hogy az öntisztulàs nagyobb mèrtèkû, ellensùlyozza, a magyarországi szennyvìz bebocsàtàst.
Az összes paramèter esetèben a szennyezôdes Szlovàkiàbòl jön. Ez a helyzet a foszfornàl 78%, a nitrogènnèl 53% ès a mikroszennyezèsek nagyrèszènèl. A magyar szakaszon a foszfor

szennyezôdès leginkàbb a falusi szennyvìzekbôl szàrmazik, mivel csak öt falunak van tisztìtò telepe. A nitrogèn szennyezôdès Magyarországon a földmûvelèsbôl szàrmazik (kb.28%).

Hernàd befogadò terülètère öt alternativ vìzminôsègi kritèriumot javasoltak. Az elsô a legkevèsbè ambiciòzus, kielègìti a jelenlegi igènyeket, ùgymint öntözèst ès àlatok itatàsàt az egesz szakaszon, valamint ivòvizkènt valò felhasznàlàst az alsò rèszen (Gesztelytôl a Sajòig). A szigorubb kritèrium (2-5) az hogy ivòvìz minöseg legyen a legnagyobb rèszen.

Az elsô alternatìva esetèben a nitrogènt fôleg az NH_4 kell erôsen redukàlni, a nikkelel egyutt.
Az ivòvìz minôsèg elèrèsèhez a BOI_5, foszfor ès kadmium koncentràciòt kell csökkenteni. A negyedik ès ötödik alternativàk esetèben az összes parametereket csökkenteni kell a mikro szennyezèsekkel eggyütt.

Ma öt tisztìtò telep mûködik, de ezek tùlterheltek igy a hatèkonysàguk kicsi. Huszonhàrom helysèg szàmàra javasoltak "WWTP" èpìtèsèt mint "hot-spots". Ez lehet 7 közös telep (elsô alternatìva), vagy külön telepet mind a 23 helysègnek (màsodik alternatìva). A màsodik alternatìva kevèsbè költsèg hatèkony. Egy tisztìtò eljàràs ami a BOI_5, nitrogènt ès foszfort eltàvolìtja, lenne a legjobb. Egy iszap kezelô telep is szàmìtàsba jött.

A mezôgazdasàgba töbfèle megoldàs jöhet szàmìtàsba mint a pontszerû (tràgyadomb) ès a diffùz (a földekrôl valò leszivàrgàs) szennyezèsekkel kapcsolatba. Ma a legnagyobb problèma a tràgya kezelèse (tràgyadomb) ahonnèt a szennyvìz elszìvàrog ès szennyezi a felszint ès a talajvizet. Sok helyen nincs megfelelô hely a tràgya tàrolàsra ès ez különbözô problèmàkat okoz. Javasoltak tràgya tartàlyokat acèl lemezekbôl, PVC bevonattal. Ez egy nagyon költsèg hatèkony megoldàs a nitrogèn, foszfor ès valòszìnüleg a BOI_5 visszatartàsàra.

Nagy problèma a földekrôl valò leszivàrgàs. Sok helyen a földek kivannak tève az eroziònak, különössen a hegyes-dombos vidèken. Tavaszi szàntàs ajànlatos ezeken a vidèkeken, hogy a növènyek gyökerei megkössèk a talajt ôsszel ès tèlen. Az ôszi vetèsbôl szàrmazò növènyek nem elèg hatèkonyak a talaj megkötèsère. A tavaszi szàntàs költsèg hatèkonysàga nem magas a foszfor esetèbe, közepes a nitrogènnèl.

Mivel ipari szennyvìz a magyarországi rèszen nincs, igy a fèmes szennyezôdèst nem tàrgyaltuk. A következô problèmàk oldhatòk meg a magyar rèszen: csökkenteni a szerves anyagokat es a tàpsòkat (N ès P), megakadàjozni az eroziòt.

Az elsô rendû feladat hogy csökkentsük az ammonium, nitrit, mangàn, vas ès nikkel koncentràciòkat
Mint màr emlitettük a fèmes szennyezèst a szlovàkoknak kell megoldani. Ha csökkentjük a mezôgazdasàgi ès a falusi szennyvizbôl eredô nitrogèn szennyezèst akkor kb. 650 tonna nitrogent(N)
tudunk eltàvolitani. A kìvànatos 800 tonna Gesztelynèl ès 1200 tonna Hidasnèmetinèl. Ez azt jelenti hogy a legteljesebb tisztìtàssal sem tudjuk elèrni a kìvànatos èrtèket. Ettôl függetlenül a 650 tonna nitrogèn eltàvolìtàsa a szerves anyagok erôs csökkentèsèvel, nagyban redukàlna az ammonium koncentràciòt, ami a legfontossab paramèter. A szerves anyagok eltàvolìtàsa csökkentenè a mangàn ès vas koncentràciòkat is. Ez az eljàràs kb. 450000 Ft.-ba kerülne èvenkènt.

A màsodik alternatìva hogy az ivòvìz minôsèget elèrjuk, a nitrogèn problèma ugyan az mint az elôzôkben, azonkìvül a foszfort 367 tonnàval kell csökkenteni Gesztelynèl. Azonban az aktuàlis ràhatàsokkal csak 60 tonnàval tudjuk csökkenteni a magyar oldalon

A nitrogèn csökkentès költsèg hatàssosàga a mezôgazdasàgban jòval nagyobb mint a szenyvìz telepeknèl.(kb. 3-50 szeresen olcsòb).

A 2 - 5 pontokba foglalt követelmènyt csak a szlovàkokkal együttmûködve lehet elèrni.

1. Introduction

1.1. Background

Hungary has 18 larger rivers and 14 of these water courses (95% of the total water amount) are transboundary. The water pollution in Hungary is therefore an international problem as well as a regional and local problem. The Hernád Watershed that is studied in this report is also transboundary and starts in the Slovakian Republic.

Surface waters and some of the groundwater in Hungary are heavily polluted by discharges from industrial, municipal and agricultural sources. The pollution causes considerable impacts on ecology and human health. The most severe problem is the bad drinking water quality.

The drinking water supply is mainly based upon ground water and infiltration from wells along the riverside, and approximately 1000 water works do not deliver water with sufficient quality.

Only half of the Hungarian population is connected to sewage systems, of which only 25% is treated (50% mechanically, 40% biological and 10% chemical). The treatment plants are heavily overloaded. There are no treatment plants with nitrogen removal. The level of treatment for industrial sources are also low.

The watercourses, which serve as a primary recipient for waste water, are often dry in long periods, resulting in infiltration of waste water to the groundwater.

To deal with these problems the Hungarian Parliament has decided that all municipalities must invest in waste water treatment plants by the year 2000. The actions proposed by the government have, up till now, only to a lesser extent considered the effects in the recipient and related the effects to the use of the water. The Hungarian parliament has also got problems with subsidising these waste water treatment plants, and a weak national economy calls for cost-efficient investments.

A strategy for an optimal pollution action plan needs to be undertaken. This plan should be recipient orientated in order to decide the level of treatment in an area, and to achieve cost-efficient solutions.

1.2. Objective of the study

There is already an ongoing Hungarian research project which aim at elaborating water quality objectives for Selected Hungarian Watersheds. Hernád is one of the prioritised watersheds and the study reported here serves as a basis for phase 2 of the national project in Hernád, but specifies also measures for major point pollution sources and diffuse pollution sources.

The objectives of the bilateral co-operation between Hungary (represented by VITUKI) and Norway (represented by NIVA) are:

- To develop tools for the elaboration of an optimal, cost-efficient strategy for water pollution abatement in Hungary in order to reduce or eliminate the negative impacts on ecology and human health.

- To develop a water pollution action plan in the Hernád Watershed based on the requirements for the use of the water. The water pollution action plan shall include measures, a review of effects, investment- and O&M costs. The measures shall be given priority based on cost-effectiveness from all main sectors.

2. The catchment area of the Hernád river

2.1. Geographical key information

2.1.1. Location, climate and land use

The Hernád watershed is transboundary and starts in the Slovakian Republic before it enters Hungary, in the north eastern part of the country near Hidasnémeti. The river flows southwards and meets Sajó which flows to Tisza (see Figure 1).

The total catchment area of the Hernád river is 5436 km^2, with only 1013 km^2 (planimetered to 1015 km^2) (19%), is located in Hungary. The total length of the river is 286 km where 108 km are in Hungary (10 km are along the border).

In the Slovakian part, the river drains agricultural areas and some major cities, with Spisska novaves, Presov and Kosice as the three largest. The Hungarian part of Hernád is dominated by flood plains, and the upper layer of the soil consist of clay, peatland and, in some areas, sand.

The middle temperature for the coldest month in the Hungarian part of Hernád is ca -3.5 °C, with the warmest month in July, 18-21 °C. The rainfall is 530-580 mm/year, and the specific run-off 21 l/s km^2. The maximum rainfall is during the summer months.

Forests cover 200 km^2 (20%) of the total catchment area and grassland, 260 km^2 (26%). The crop area are predominantly tilled, and consists of 410 km^2 (41%). Built-up areas (roads, towns and villages), water areas, riverbanks etc. cover 137 km^2 (13%).

Agriculture is one major activity and the main crops are winter-wheat, maize, sunflower, lucern, rape, potatoes and barley.

The total population in the Hernád catchment is approximately 64 000. There are 72 municipalities within the catchment where the largest villages are Böcs (2643), Encs (6663), Gesztely (2753), Gönc (2378) and Forró (2239). These five villages constitute 26% of the total population, showing that the total number of small villages are high. The largest villages are situated along the Hernád river.

Figure 1. Catchment area of the Hernad river

There are some industry in the catchment, mainly small industries and enterprises. The largest are the brewery located at Böcs and a metallurgical plant, Pankl Hoffman producing screws, located at Onga.

2.1.2. Recipient areas/sub-catchment areas

The catchment area is divided into 3 recipient areas or sub-catchment areas (see Figure 2). Different criteria have been used to determine the borders for these recipient areas.

It has been considered important to define areas in which natural conditions and user interests/conflicts are as homogeneous as possible. The borders should correspond to the extend possible to the stations of water quality measurements.

The main aim of the division into recipient areas is to provide a basis for:

- evaluating pollution status
- evaluate the need to introduce measures to achieve satisfactory water quality for various user interests
- determining water quality goals.

The recipient areas are presented in Table 1.

Table 1. Recipient or sub-catchment areas for the Hernád river in Hungary.

Recipient area	**Size, km^2**
Border of Slovakia - Vizsoly	293
Vizsoly - Gesztely	613
Gesztely - mouth	109
TOTAL	**1015**

The sum, 1015 km^2 (which is a result of planimetration on 1:100 000 map), corresponds quite well with the official 1013 km^2.

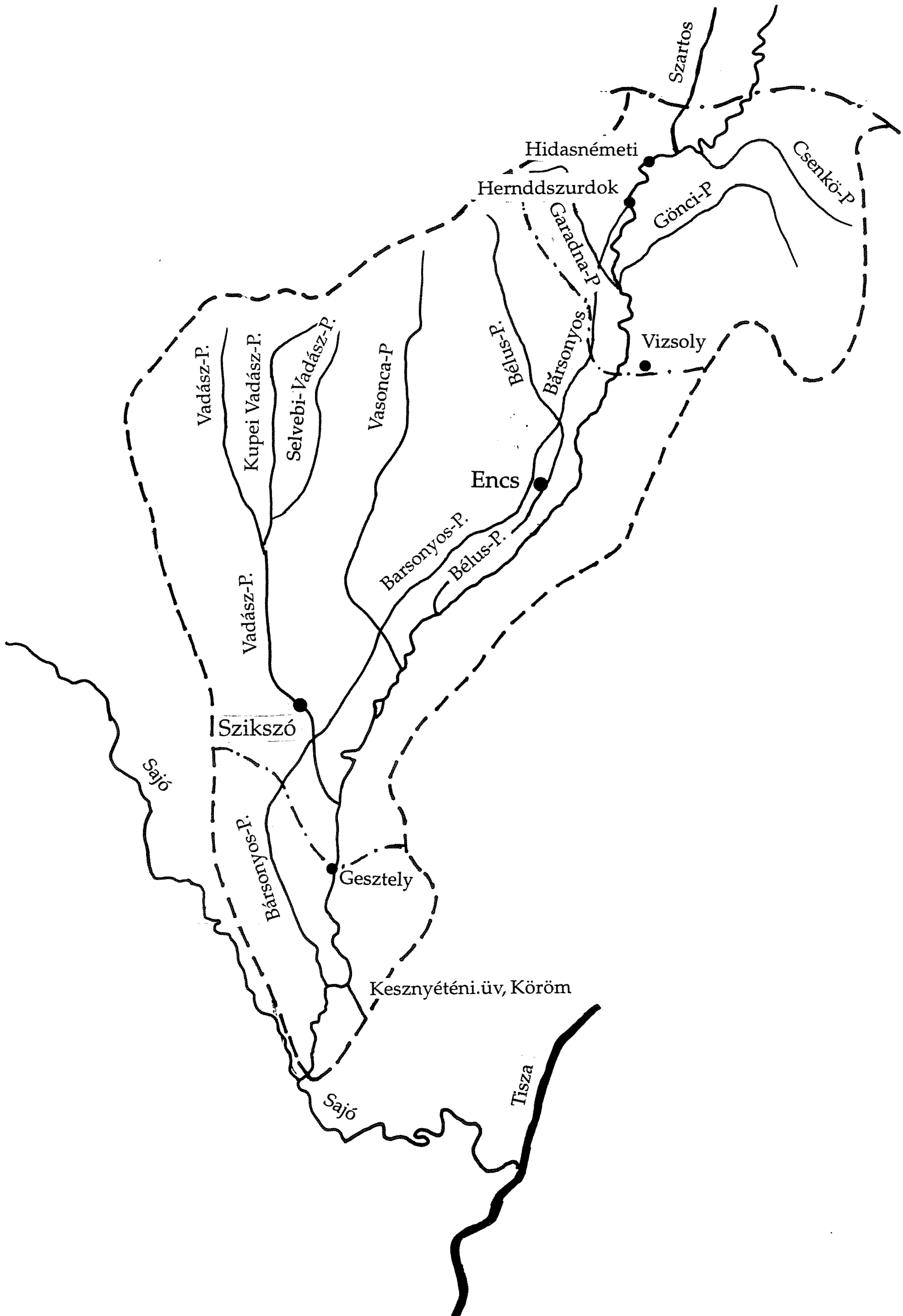

Figure 2. The river Hernád in Hungary with its recipient areas.

2.2. Water Resources

2.2.1. Rivers

The Hernád river is rather slow flowing with an average fall of 3 meter/km. This cause meanders in some parts of the river, and the total length of the river is 30% greater than the total length of the valley. The sediment transport is high, about 820 000 tonnes/y at Hidasnémeti and 473 000 tonnes/y at Gesztely.

The main tributaries to the Hernád river are in the Slovakian part (see Figure 3). Figure 3 also shows the size of the sub catchments. The vertical axis shows where the main tributaries enters Hernád River. Detailed information on the rivers in the Hungarian part can also be found in Table 2.

Table 2. Tributaries of the Hernád.

Tributary	River km. (connection)	Length (km)	Sub Catchment (km^2)	Total (km^2)
At the border of Slovakia				4226
Csenko-creek	102	18	38	4318
Szartos	97	14	129	4514
Gönci-creek	86	21	63	4605
Garadna	84	13	36	4641
Bélus-creek	51	32	77	4779
Vasonca-creek	44	27	95	4889
Vadász-creek	29	34	211	5125
Bársonyos m.cs.	11	68	231	5419
Hernád at Sajó	0	286	1013	5436

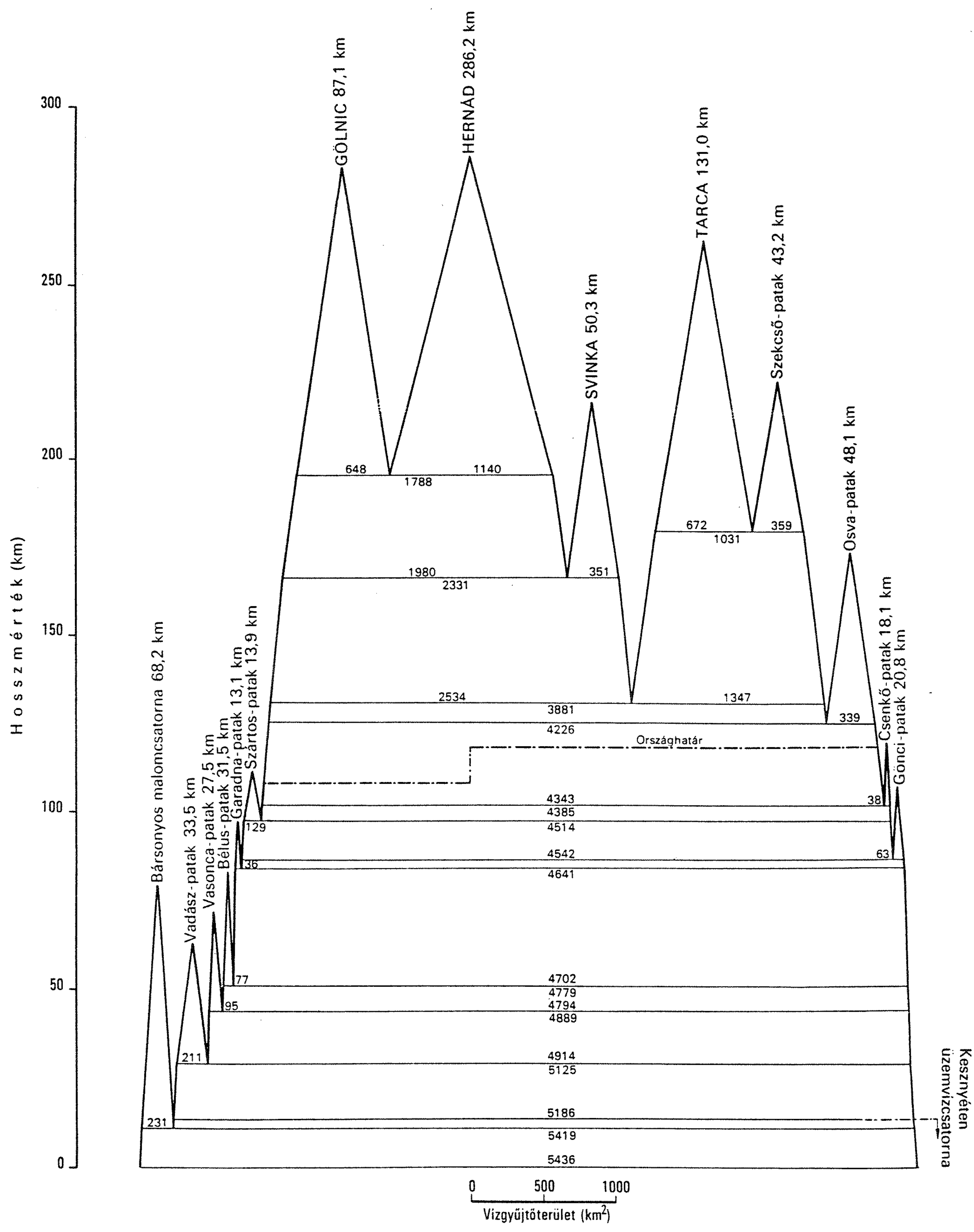

Figure 3. Areas and length of the catchment area, river and tributaries (pataks).

2.2.2. Groundwater

The groundwater level is quite high in the river bank areas (flood plains), which cover a large part of the crop area. The ground water is mostly used as drinking water (river bank infiltrated). Along the river, there are both small and large water works. One of the larger water works, that supplies several villages or municipalities, is located in Gesztely.

2.2.3. Reservoirs

There is only one reservoir in the catchment area, Szártos Reservoir, which is mainly built for reducing the adverse effects of waste water from Slovakia before this enters the Hernád river via Szártos Creek.

3. Water Resource Management

3.1. Organisations and institutions

3.1.1. National, District and Local water management

Figure 4 shows a simplified picture of the organisation of the water resource management in Hungary. Only the two most central authorities are shown; "the Ministry of Transportation, Telecommunication and Water Management" and "the Ministry of Environmental Protection and Regional Policy". These two Ministries have two administrative bodies "the National Water Authority" (NWA) and "the Environmental Protection Inspectorate" (NEPI).

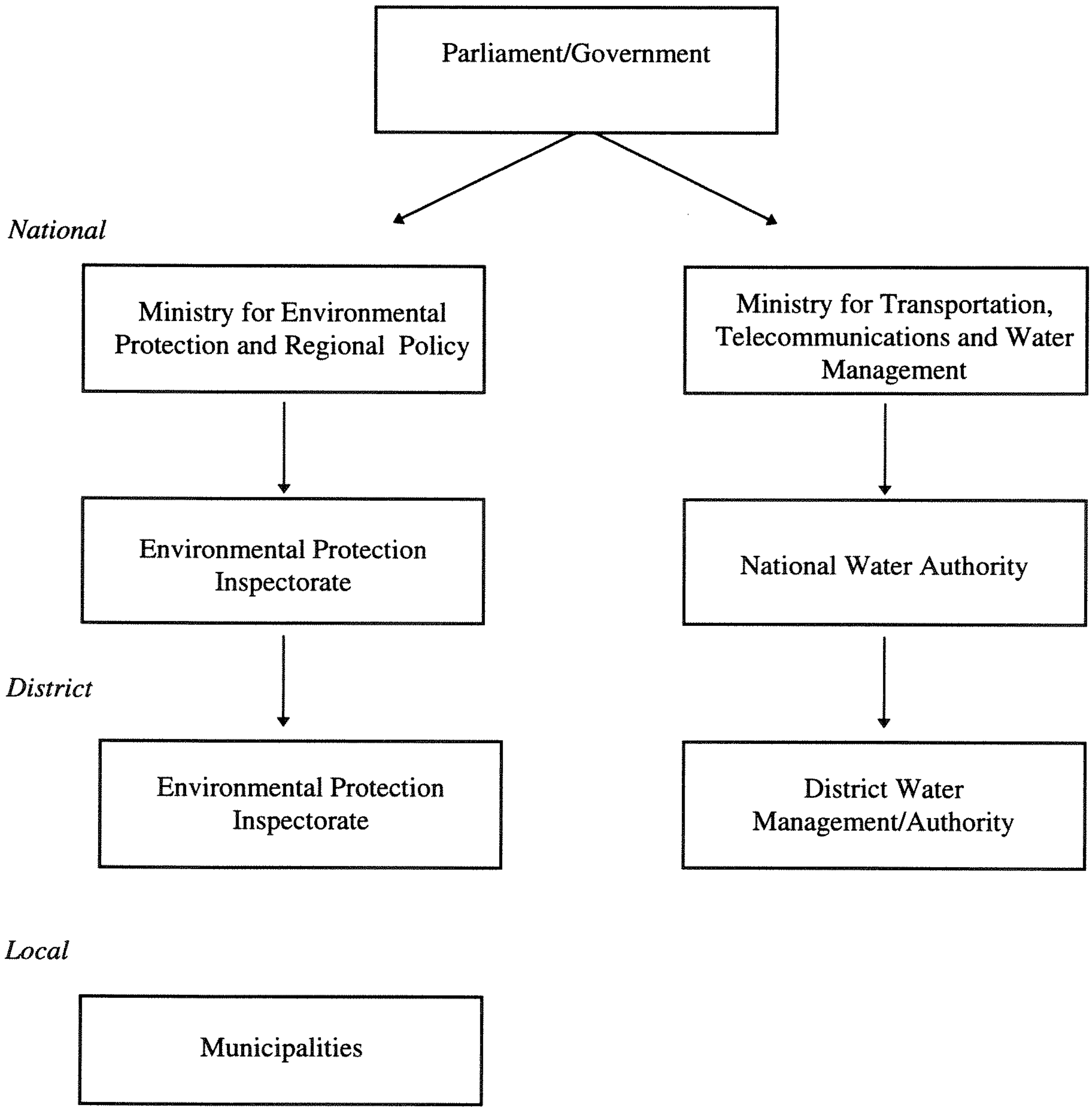

Figure 4. Water Management Authorities.

The NWA and the NPI have 12 regional units. The District Water Management Authority (DWA) and The District Environmental Protection Inspectorate (DEPI) located in Miskolc are two of these and cover Borsod-Abaúj-Zemplén county and parts of Heves, Szolnok and Nográd Counties. The two regional offices cover the same area, and are catchment oriented.

Water is a public property in Hungary and every measure which interfere with the water quality and quantity needs to be permitted.

3.1.2. The Environmental Protection Inspectorate in Hernád

The Environmental Protection Inspectorate is responsible for several fields related to environmental protection and is divided into three departments (see Figure 5).

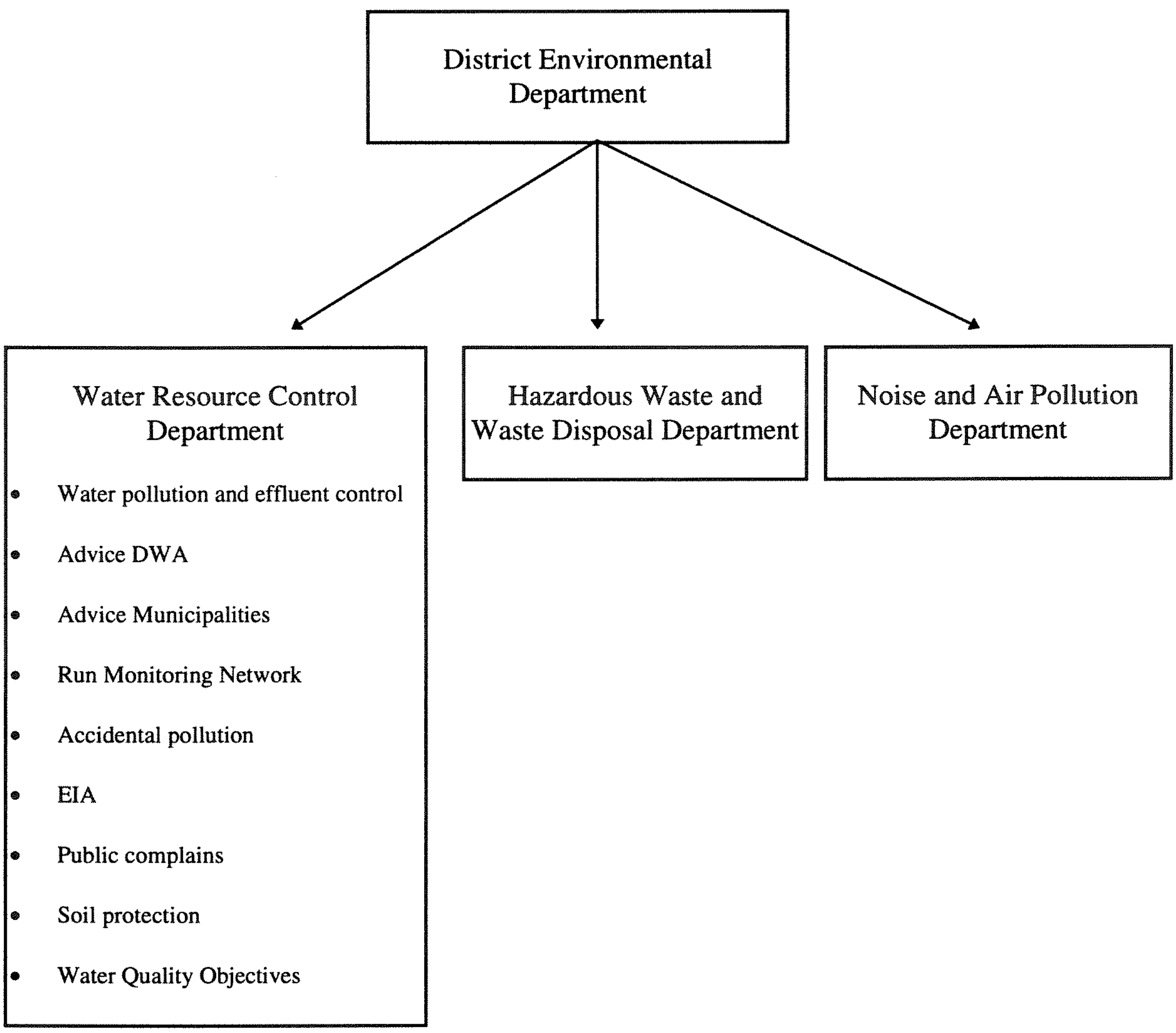

Figure 5. Organisation of the District Environmental Inspectorate

The Water Resource Control department is divided into two sections; The Surface and the sub surface section. The main tasks are described below.

- Water pollution and effluent control

The Environmental Inspectorate controls the water quality in the recipient and evaluates compliance with the water quality standards. The DEPI also controls the effluent from polluters in order to assess whether they comply with the discharge permits given.

Every municipal WWTP discharging more than 200 m^3/day, as well as large industries, are controlled regularly. Smaller polluters are controlled if there are some indications or complains about pollution. The Inspectorate can issue fines if the permits are not complied with. The fees and fines are calculated by the end of each year and based on the measurements taken twice a year by the Inspectorate. The measures taken by the Inspectorate are also compared with the self-control measurements carried out by each polluter.

If the standards are exceeded the Inspectorate will require that the polluter surveys the extension of the problems and proposes some measures. The measures will in next turn be evaluated by the Inspectorate and the polluter might be enforced to implement some measures within a given time schedule. The polluter must report to the Inspectorate when the goal is achieved.

- Advice DWA

When a new water permit/discharge permit is given or renewed, the Inspectorate advise DWA regarding water use, the need for a certain water quality in the recipient (according to the standards or other water quality objectives), waste disposal and effluent quality.

- Advice Municipalities

The permits for establishing private owned septic tanks or other private sewage systems (<1.5 m^3/day), are given by the municipal council. The Environmental Inspectorate advises the municipalities and encourages them to co-operate and establish regional sewage systems, regional WWTP and sludge disposal facilities.

It is the owners responsibility to construct water proof septic tanks, but the tanks must be tested and issued with a certificate before they come into operation. The Inspectorate/municipality can enforce individuals to document the functionality of the septic tank.

The municipality establishes routines for collection of the sludge from the individuals septic tanks, but the waste disposal area must be determined by the Inspectorate.

- Running of monitoring network

The Inspectorate runs a monitoring network which is a part of the national monitoring network

- Accidental pollution

It is the responsibility of the Environmental Inspectorate to give professional assistance and lead the operation in case of accidental pollution. They must also inform the municipalities which are affected by the pollution.

- EIA's

In the cases of new projects, like building of gas pipes, roads, the closing down of mines and establishing of gas filling stations, the DEPI must evaluate the consequences and carry out an environmental impact assessment.

- Public complains

Each year the Inspectorate has to handle public complains including those from anonymous persons. It turns out that only 50-60% of these complains represent real problems.

- Soil protection

In accordance with the privatisation law the owner of land must hand over properties with unpolluted land when this is sold to a new owner. The Inspectorate guide the present owner regarding clean up actions

- Setting water quality objectives

It is the responsibility of the Inspectorate to set water quality objectives according to the user interests in the recipient area. The objectives have so far been set according to the water quality standards.

The national water quality objective programme (see chapter 3.2.1), will give the Inspectorate an opportunity to have a more differentiated approach to the pollution problems.

The Inspectorate has no jurisdiction over the agricultural business, not even the pollution from point sources, manure tanks etc.

<u>The Inspectorate wants to meet the following requirements for Hernád:</u>

-Supply drinking water quality in the whole water shed or, as a minimum, in Böcs where surface water is extracted for drinking.

-Supply water suitable for irrigation in the whole length of Hernád in Hungary.

-Supply water suitable for recreation from Vizsoly to the mouth.

There is not determined any requirement connected to <u>water quality class</u> .

The Inspectorate therefor encourages:

- Reduction of pollution load from the Slovakian Republic by means of bilateral agreements
- Building of sewage systems in rural areas to reduce the pollution to groundwater and surface water.

3.1.3. The District Water Management Authority in Hernád

The District Water Management Authority issues permits for water use and discharges, and has the overall responsibility for the operation and maintenance of the watershed including flood control and management of artificial irrigation and drainage channels. The DWA consists of 4 departments (see Figure 6).

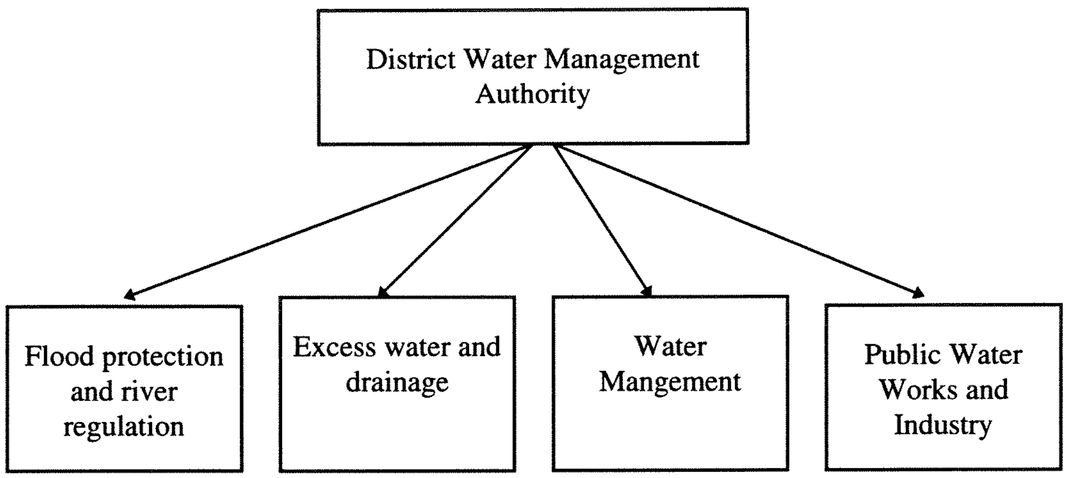

Figure 6. The organisation of the district water management authority

DWA issues water extraction and discharge permits (every outlet larger than 1.5 m^3/day).The discharge permits are given according to the prioritised surface and sub surface category (see chapter 3.2.2). The surface water in Hernád is categorised as class II.

The DWA also collects information and keeps record on all water rights and discharge permits larger than 5 m^3/h or 80 m^3/day.

The department issues rights for public water works and calculate their fees. The water supply fees for the industry depend on the process.

They also advice the municipalities on construction of waste water treatment plants.

3.1.4. Municipalities

The responsibility for water supply and waste water collection and treatment have been delegated to the municipalities. The municipalities issue building permits, but the water use and discharges must be approved by the DWA. They have also a reporting responsibility to the DWA and the DEPI.

The Municipal council can issue permits for separate sewage systems when these are less than 1.5 m^3/day. Permission for closed sewage collection tanks can be given by the municipal council , even if the daily flow is larger the 1.5 m^3/d.

The Municipal council is responsible for establishing routines for collection of sludge.

3.2. Legal, economic and planning tools

3.2.1. The national research programme on determination of surface water quality objectives

There is already an ongoing Hungarian research project which aims at elaborating water quality objectives for Hungarian Watersheds.

The project evaluates the need for reduction in the total pollution loads in order to achieve alternative water quality objectives. It will serve as a basis for discharge permits in the future. This will secure a recipient oriented approach.

3.2.2. Legal framework and regulations

The Act on Protection of the Environment

The Act on Protection of the Environment from 1976 was revised in May 1995. The aim of this act is to provide all inhabitants in Hungary with a sound environment. It is an overall law for protection of the natural resources, including protection against pollution.

The Water Act of 1964

The Water Act focuses mainly on quantitative aspects and less on the qualitative aspects. The act is supposed to protect the water resources against adverse impacts, but it focuses mainly on adverse effects in relation to floods and droughts.

This act is under revision and will focus more on the qualitative aspects and on a comprehensive water resource management in the revised version.

Discharge permits and effluent standards related to prioritised surface and sub-surface areas

The surface and subsurface resources in Hungary have been prioritised according to five categories. Hernád is highly prioritised and is in category II. For each recipient category effluent standards have been developed and the discharge permits have been given according to them. The effluent standard gives concentrations only for limits and not for the amount of pollution.

Discharge permits according to the objectives for the recipients

Today, the discharge permits are standardised, as described above.

The national project executed by VITUKI allows a more recipient oriented approach where the water management authority must consider the objectives for the recipient, the quality and flow of each outlet before issuing permits. The present standards might function as minimum standards.

Separate sewage systems

As mentioned above the municipalities can issue rights to establish separate sewage systems as long as the outlet is less than 1,5 m^3/d. This represents an outlet from 15 persons or an outlet from 5 houses (an average consumption of 100 l/pd and 3 person per family). There are no regulations regarding how many of these individual outlets which can be within one area. This means that large municipalities can discharge their sewage into surface water as long as the individual outlets are less than 1,5 m^3/d. The inspectorate is aware of this situation.

The routines for collecting the sludge from separate sewage system are not regulated by any law, and there are no requirements for the maximum allowable time between two collections.

Industrial pollution

As long as the industrial pollution has the same characteristic as the municipal waste water, it can be discharged to the municipal sewage system and treated together with the municipal waste water. The concentration limits for the substances in the effluent are the same for industrial water as for municipal waste water.

Agriculture pollution

Agriculture activities are also regulated by the water act, but in practice it has been only the large scale husbandries which have been fined for pollution.

As good as no attention has been paid to manure storage, silage effluent, area run off etc.

Spreading of manure is not allowed outside the growing season and not in the winter months from December-February. However the regulations regarding the spreading of manure on frozen fields does not function because of lack of storage capacity.

3.2.3. Economic instruments and funds

Water extraction fees, discharge fees and pollution fines are implemented to reduce the water extraction and the pollution.

The revenue goes back to the national budget.

The Central Environmental Fund, which is financed by the national budget, is supporting municipalities as to collection and treatment of municipal waste water in vulnerable areas (especially in areas where the groundwater is protected).

In addition to the Central Environmental fund there exist several other funds for allocating money to the municipalities in building of sewage systems such as the Utility Development Fund, the City Development fund, the Water Fund.

3.2.4. Strategy and prioritisation, municipal waste water

The Hungarian Parliament decided in 1991 that all municipalities must invest in waste water treatment plants within the year 2000 with a guaranteed 50% funding from the state.

Today one has realised that this goal can not be achieved and the Parliament has decided to support only municipalities with special environmental problems. The municipalities are grouped in different categories.

It is up to the municipalities to apply for funding both for the sewage system and the waste water treatment plants. The Parliament has ranked them and decided on its funding in the period 1995-1997.

4. Water quality and effects

4.1. The Hungarian classification system

4.1.1. Water quality criteria

Water Quality Classes

The surface water quality is classified according to the standard MSZ 12749 "Quality of Surface Water, quality characteristics and classification". This classification system was enacted in January 1994.

The water quality is classified according to five classes, as follows;

Class I: Very good water quality
The water is naturally pure and contains no pollution, is almost 100% oxygen saturated, has a low content of dissolved solids and nutrients and contains no faecal bacteria.

Class II: Good water quality
The water contains only small amounts of pollution and nutrients, and is characterised as mesotrophic. The yearly and daily variations of suspended organic and inorganic matter, and the influence of domestic waste water are not harmful to aquatic organisms. The biodiversity is high and the number of each specie is low. There are no smell or taste from the water and the number of faecal bacteria is low.

Class III: Acceptable water quality
The water is moderately affected by pollution. Organic matter and nutrients can cause eutrophication. Faecal bacteria can be identified. The yearly and daily variations in oxygen content and harmful components can periodically cause bad living conditions for water organisms. The biodiversity is reduced and the mass blooming of some species can discolour the water and cause smell and taste .

Class IV: Polluted water
The water is affected by sewage and has a high content of organic matter, nutrients and faecal bacteria. The oxygen saturation varies, but anaerobic conditions can occur. The organic load causes mass blooming of hetrotrophic species, discolouring and turbid water. The concentration of micro-pollutants can reach toxic levels and the water quality is harmful to plants and multicellular water organisms.

Class V, Very polluted water
The water is very polluted with organic and inorganic matter and can have a high toxicity. The water quality can be compared to "raw sewage". Lack of oxygen reduces the living conditions for aquatic organisms. The water is turbid and has a reduced transparency. The pollution discolour the water and the water smells. The water quality can be chronic or acute toxic to organisms.

Parameters and classification

The water quality parameters can be divided into 5 groups:

A: Oxygen parameters.
B: Nitrogen and phosphorus compounds and chlorophyll a.
C: Coliform bacteria.
D: (D1-D4), Heavy metals and other micro-pollutants.
E: Basic chemical and physical parameters.

The water is classified according to the C_{90} value and it is the worst parameter in each parameter group which is used for classification. The C_{90} value is calculated on the basis of minimum 12 samples, and the next to the highest value is used as a basis. The C_{90} value expresses the maximum concentration (90 percentile) during a year, and the probability for one parameter of exceeding less than 10%.

The Hungarian classification criteria for some of the parameters are shown in Table 3:

Table 3. Classification according to MSZ 12749 and the C_{90} value

Parameter	**The Hungarian classification system for water quality MSZ 12749**				
	I	II	III	IV	V
BOD_5 (mg/l)	<4	<6	<10	<15	>15
COD_{Mn} (mg/l)	<5	<8	<15	<20	>20
COD_{Cr} (mg/l)	<12	<22	<40	<60	>60
TOC (mg/l)	<3	<5	<10	<20	>20
Tot-P (mg/l)*	<0.1	<0.2	<0.4	<1.0	>1.0
Tot-P (mg/l)**	<0.040	<0.100	<0.200	<0.500	>0.500
$N\text{-}NH_4$ (mg/l)	<0.2	<0.5	<1	<2.0	>2.0
$N\text{-}NO_3$ (mg/l)	<1.0	<5	<10	<25	>25
Σ(N-NH4+N-NO3) (mg/l)	<1.2	<5.6	<11.2	<27.5	>27.5
Fe (mg/l)	<0.1	<0.2	<0.5	<1.0	>1.0
Mn (mg/l)	<0.05	<0.1	<0.1	<0.5	>0.5
Cd (µg/l)	<0.5	<1	<2	<5	>5
Hg (µg/l)	<0.1	<0.2	<0.5	<1.0	>1.0
Pb (µg/l)	<5	<20	<50	<100	>100
Cu (µg/l)	<5	<10	<50	<100	<100
Zn (µg/l)	<50	<75	<100	<300	>300

*Rivers which do not flow into lakes or water reservoirs
** Other

A comparison between the Hungarian and the Norwegian criteria has been done. This is shown in Appendix Table A1. The Norwegian system uses mean average concentrations (C-average) as basis for classification, and mean average is also used in the classification.

Most of the parameters in the Hungarian system allow higher concentrations than the Norwegian system. This is not surprising, bearing in mind the different natural conditions and the general level of pollution. There is, however, especially one parameter that allows very high levels in the

Hungarian system. This is phosphorus, and the reason could be that other factors than P often is the limiting factor for eutrophication. These factors could be light limitation (because of the high level of siltation), and in some cases the general level of micropollutants (such as heavy metals) which could have a direct toxic effect on the algae and therefore reducing the eutrophication effect.

However, when measures to reduce micropollutants are enforced, especially in the industrial sector, and measures are being implemented to reduce the siltation problem, the eutrophication problems may paradoxically become even greater. This indicates that the limit values for phosphorus need to be revised.

4.1.2. Classification of water related to the use of water

The water can also be classified according to the suitability of use, and VITUKI has made a proposal for some new developed criteria for different user interests; drinking water (raw water and tap water), industry, recreation and swimming, irrigation, animal watering, fishing and biodiversity.

The water is classified in two classes according to the suitability for use, Class 1: "Preferred water quality" and Class 2: "Acceptable Water Quality". The limits for some of the parameters for different use are shown for some of the parameters in Appendix Table A2. The Table does also show the corresponding water quality class. The classification according to the use of water is very liberal compared to the water quality classification system, and it seems necessary to harmonise these two systems.

Table 4 shows a comparison between the Hungarian classification system for drinking water and the system in other countries/organisations. The Hungarian system contains a large number of parameters. Some of the parameters could be omitted regarding some of the user-interests, at least there could be stated which parameter which is the key parameters.

Table 4. Drinking water classification within different countries/organisations compared with the Hungarian MSZ 12749

Parameter	Norwegian 1)		EU		WHO		US-EPA		Canada		Hungarian 1		Hungarian 2	
	Limit	Class	Limit	Class	Limit	Class	Limit	Class	Limit	Class	Limit	Class	Limit	Class
BOD (mg/l)											3	I		
Ammonium, NH_4-N (mg/l)	0.5	II	0.5	II							0.04	I		
Nitrite, NO_2-N (mg/l)	0.05	III	0.03	II					1	V				
Nitrate, NO_3-N (mg/l)	10	III	11.3	IV	10	III	10	III	10	III	5.65	III	11.3	IV
Coliform (pr/100ml)	3	I	10	I	0	I	1	I	0	I	50	I		
Fekal C (pr/100ml)	1	I									20	I		
Phosphorus* (mg/l)	0.011	I	5	V										
P-PO_4 (mg/l)											0.18	III		
Chlorophyll (μg/kl.a/l)	0.0037	I												
Aluminium (mg/l)	0.1	III	0.2	III	0.2	III								
As (μg /l)	10	I	50	III	50	III	50	III			10	I	50	III
Hg (μg /l)	0.5	III	1	IV	1	IV	2	V	1	IV	0.5	III	1	IV
Cd (μg /l)	5	IV	5	IV	5	IV	1	II	5	IV	1	II	5	IV
Ni (μg /l)			50	III										
Zn (μg /l)	300	IV			5000	V	5000	V	5000	V	500	V	3000	V
Pb (μg /l)	20	II	50	III	50	III	50	III	50	III			50	III
Cr (μg /l)	50	IV	50	IV	50	IV	50	IV	50	IV			50	IV
Cu (μg /l)	300	V		V	1000	V	1000	V	1000	V	20	III	50	III
Fe (μg /l)	200	II	300	III	300	III	300	III	300	III	100	I	300	III
Mn (μg /l)	100	II	50	I	100	II	50	I	50	I	50	I		

1)From 1995 the EU criteria are valid also in Norway

4.2. Classification and effects

4.2.1. Monitoring stations

Monitoring in Hernád Watershed has been undertaken by VITUKI at three stations namely 1)Hidasnémeti, 2)Hernádszurdok and 3) Gesztely (see Figure 2) in the period 1982-1992.

Several parameters have been measured; water flow and other physical parameters, basic chemical parameters, organic matter (BOD, COD, TOC) and oxygen, nitrogen and phosphorus compounds, chlorophyll, heavy metals and other micro-pollutants.

The C_{90} values from the stations in the period 1989-1992 has been calculated and used for classification of the present water quality.

The water quality in the mouth and in Vizsoly has not been estimated or calculated. This is however possible, based on the pollution load and average selfpurification coefficients.

The water quality in Hidasnémeti and Gesztely have been used to calculate the need for reduction of pollution in the three recipient profiles: Vizsoly, Gesztely and the mouth (see chapter 6).

4.2.2. Status in Hernád river

Hernád river and its tributaries are very polluted by organic matter, nitrogen (especially ammonia, but also nitrate), phosphorus, iron, manganese and heavy metals. The cadmium content is particularly high, but also mercury, lead, chromium and copper. Table 5 and Table A2 in the appendix give the concentrations for the most important parameters. The sediment transport in the river is also very high.

Table 5. Water quality in Hernád main river and some tributaries (creeks). C_{90} values over the four last years (1988-92).

Profile	Group A : Oxygen Parameter				Group B : N - P Eutrophication						
	O_2 m.	BOD_5	COD_{Mn}	CODCr	$N\text{-}NH_4$	$N\text{-}NO_2$	$N\text{-}NO_3$	Tot-N	$P\text{-}PO_4$	Tot-P.	Chl.-a
	%	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	
Main river:											
Hidasnémeti	138	8,80	7,7	28,0	3,9	0,36	4,1	9,37	0,49	0,57	17,12
Hernádszurdok	138	8,80	7,2	24,6	3,8	0,36	4,2	9,57	0,52	0,57	21,32
Gesztely	118	7,77	6,4	22,0	2,4	0,14	4,5	9,10	0,42	1,70	69,60
Tributaries:											
Bélus-creek			97,3	270,8	57,9		58,9				
Gönci -creek			49,0	115,5	30,6		1,2				
Vadász-creek			82,1	191,8	100,3		54,0				
Hernád diversion canal			24,5	47,7	8,7		12,2				
Bársonyos canal			15,7	41,3	1,0		10,9				
Bársonyos canal			(-)	183,9	89,1		11,5				
Main river:											
Hidasnémeti	III	III	II		V	V	II		V	V	II
Hernádszurdok	III	III	II		V	V	II		V	V	III
Gesztely	II	III	II		V	IV	II		V	V	III
Tributaries:											
Bélus-creek			V	V	V		V				
Gönci -creek			V	V	V		II				
Vadász-creek			V	V	V		V				
Hernád diversion canal			V	IV	V		IV				
Bársonyos canal			IV	IV	IV		IV				
Bársonyos canal			(-)	V	V		IV				

Profile	Group D : Inorganic Micropollutants								Group E : Div. parameter			
	Hg	Cd	Ni	Zn	Pb	Cr	Cu	As	Mn	TS	SS	Fe
	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	mg/l	mg/l	mg/l	mg/l
Main river:												
Hidasnémeti	0,28	3,0	25,9	140	25,8	20,1	19,9	7,8	0,31	457	139	2,3
Hernádszurdok	0,23	3,0	25,2	116	23,2	15,0	16,7	8,9	0,32	479	131	1,8
Gesztely	0,21	2,3	28,2	114	25,0	11,8	14,3	8,6	0,30	486	99	2,0
Tributaries:												
Bélus-creek										1106	116	
Gönci -creek										1164	62	
Vadász-creek										1533	124	
Hernád diversion canal										889	33	
Bársonyos canal										918	30	
Bársonyos canal		90,0	87,0	77420	4,0		51,0			2665	127	6,64
Main river:												
Hidasnémeti	III	IV	II	III	III		III	I	IV			V
Hernádszurdok	III	IV	II	III	III		III	I	IV			V
Gesztely	III	IV	II	III	III		III	I	IV			V
Tributaries:												
Bélus-creek												
Gönci -creek												
Vadász-creek												
Hernád diversion canal												
Bársonyos canal												
Bársonyos canal		V	V	V	I		III					V

The selfpurification is considerable for several of the substances, especial nitrogen, phosphorus and organic matter. Generally the water quality is improving with increasing distance from the Slovakian border. This is due to dilution and selfpurification processes, and the rather small loads from the Hungarian side.

This is also shown in Figures 7 and 8.

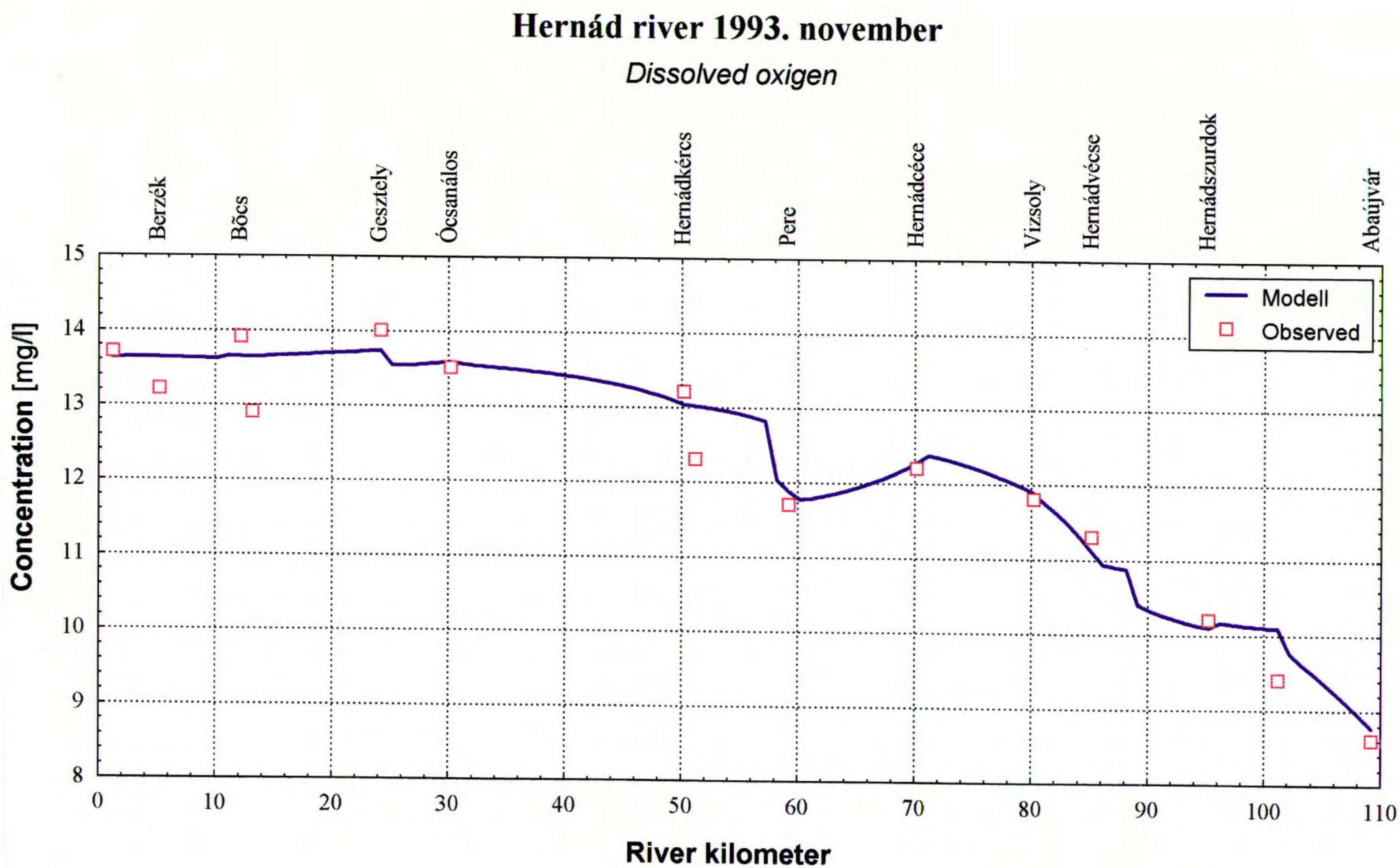

Figure 8. Model simulations (QUAL 2) and observed concentrations of dissolved oxygen in Hernád from the border of Slovakia (to the right) and to the mouth. (Source: VITUKI).

4.2.3. Quality of groundwater

There has not been possible to get any water quality data of groundwater, but problems with iron and manganese in the groundwater and some problems with arsenic have been mentioned. There is also reason to believe that there in some areas could be high levels of nitrate.

5. Pollution sources

5.1. Domestic Waste Water and Industry

5.1.1. Domestic Waste water and outlets from WWTP

The coverage of public sewage systems is low. Only 5.5 % of the population is connected to public sewage systems. The sewage is treated together with industrial effluent either mechanically (3%) or in biological waste water treatment plants (97%). People who are not connected to public sewage use septic tanks which is the far most used "treatment" in the region (Table 6).

Table 6. Waste water handling in the Hernád Watershed

Number of people	% of tot. population	Waste water treatment
60789	94.5	Septic tanks
133	0.2	Sewage system and mechanical treatment
3597	5.4	Sewage system and biological treatment

The sewage system is based on separate systems, and the collection of stormwater is negligible. There are only 1.2 km with combined sewage systems in the whole catchment.

Table 7 shows the treatment plants, amount of waste water treated at the plants (grouped into industrial and domestic waste water) and the total number of people using septic tanks or discharging to the waste water treatment plants in the three recipient profiles. Table 8 shows the treatment processes at the plants.

Table 7. Waste water handling and waste water treatment plants in the recipient profiles

Treatment plant	Population (p.e.)			Treatment			Domestic	Industry	Industry/ domestic
	Vizsoly[1)]	Gesztely	Mouth	Mech. [%]	Biol. [%]	Septic [%]	m^3/d	m^3/d	[%]
Böcs WWTP			191		100		282	0	0
Encs WWTP		2731			100		310	176	57
Gönc WWTP	118			100			17	32	188
Hidasnémeti, WWTP	32			49	51		9	105	1166
Szikszo, WWTP		459			100		78	188	241
Rural areas	11125	36239	13426			100	6079	0	0

1)The figures for Vizsoly also include population upstream Hidasnémeti to the border of the Slovakian Republic

Table 8. Technical data for WWTP

Treatment plant	Capacity m^3/d	Screen	Activated sludge/ sedimentation	Acti-vated sludge	Sedi-men-tation	Dis-infection	Reported Treatment efficiency [%][2]			
							BOD	SS	Tot-P	Tot-N
Böcs	179	x		x	x	x	-	-	-	-
Encs	1000	x	x			x	70	65	-	29
Gönc	80				x[1]	x	40	60	-	12
Hidasnémeti							-	-	-	-
Szikszo	452	x	x			x	70	67	-	-

1) Septic tank

2) Based on calculations of inlet quality and outlet quality. The inlet quality is very approximate while the outlet quality is measured in the river. The treatment efficiencies have been adjusted to the differences between the inlet flows and the river flows.

The data in Table 8 seems to indicate that the biological waste water treatment plants are operating as biological high load plants (see 7 "normal" treatment efficiency at waste water treatment plants). The outlet qualities and inlet qualities at the plants are however rather uncertain and are not used to calculate the total loads from the plants.

The total loads from the waste water treatment plants are based on the treatment efficiencies shown in Table 9, the calculated domestic pollution production and the calculated pollution from industry. The criteria used for calculating domestic pollution production are summarised in Table 10.

It is assumed that the waste water from the industry in the area has the same quality as the domestic waste water. The pollution load from industry is calculated by using the relative differences in water flow from the industries compared to the total amount of domestic waste water at the plants (see Table 8)

Table 9. Treatment efficiency [%]

Plant	BOD	SS	Tot-P	Tot-N
Mechanical	30	60	15	15
Biological (hi-l)	70	80	30	25
Biological (lo-l)	90	85	30	30
Septic tanks	30	40	5	5

Table 10. Specific production

Q(l/pd)	Qdim(l/pd)	BOD(g/pd)	COD*(g/pd)	SS (g/pd)	Tot-P(g/pd)	Tot-N(g/pd)
100	200	62.5	160	62.5	2.5	12

*BOD/COD≅0.4

The total pollution loads from rural areas and from the waste water treatment plant are shown in Table 11.

Table 11. Pollution loads (tonnes/year)

	Border - Vizsoly[2)]					Vizsoly - Gesztely					Gesztely - mouth				
	BOD	COD	SS	Tot-P	Tot-N	BOD[1)]	COD	SS	Tot-P	Tot-N	BOD[4)]	COD	SS	Tot-P	Tot-N
Böcs											1.3	3.3	0.9	0.1	0.6
Encs						29.3	73.3	19.6	2.7	14.1					
Gönc	5.5	13.7	3.1	0.3	1.3										
Hidasnémeti	4.4	10.9	2.6	0.3	1.4										
Szikszó						10.7	26.8	7.2	1	5.2					
Rural areas	177.6	444.1	152.3	9.6	46.3	578.7	1446.7	496	31.4	150.8	214.4	536	183.8	11.6	55.9
Total	187.5	468.8	158	10.2	49	618.7	1546.8	522.8	35.2	170	215.7	539.3	184.6	11.8	56.5

1 BOD/COD=0.4

2)Including also pollution upstream Hidasnémeti to the border to Slovakia

Table 12 and appendix tables A3 and A4 show the total pollution load to the recipients from the different sectors.

Table 12. Total pollution loads from municipalities and industry connected to public sewage systems.

	BOD [tonnes/y]	COD [tonnes/y]	SS [tonnes/y]	Tot-P [tonnes/y]	Tot-N [tonnes/y]
Public Sewage, domestic	25.4	63.4	16.7	2.3	11.7
Public Sewage, Industry	25.8	64.6	16.6	2.1	10.8
Rural areas	970.7	2426.8	832	52.7	252.9
Total	1022	2555	865	57	275

5.1.2. Industry

There are only some smaller industries in the area, and they are connected to the public sewage system. The contribution from these are calculated in the previous chapter.

One exception is Pankl-Hofmann, which are producing screws and is discharging directly to the river. The yearly discharges from this plant are shown in Table 13. They are based on effluent data (VITUKI, 1995).

Table 13. Discharge from Pankl-Hofmann

Parameter	Discharge
COD Mn (tonnes/year)	0.5
SS(tonnes/year)	1.5
Tot-P (tonnes/year)	
Tot-N (tonnes/year)	0.5
Fe (kg/year)	116
Cu (kg/year)	0.5
Pb (kg/year)	0
Cd (kg/year)	0.5
Ni (kg/year)	0.7
Zn (kg/year)	490

5.2. Agriculture

There are no official statistics for the agricultural sector since 1989. The data and material on agriculture that are referred to in this report are provided by the Agricultural and Soil Protection Agency in Miskolc, through VITUKI. Some of the data are based on regional areas (counties), and not the catchment areas.

5.2.1. Growing pattern

The dominant production in the area is one year crops, where the land is levelled every year, such as winter wheat, spring wheat, barley, maize, potatoes and sunflower. There are also some orchard. The grassland represent about 40% of the total catchment area. This is shown in Table 14. No figures on the production of barley has been provides, although our excursion to the area in late June 1995 revealed that this was grown over quite large areas. The winter wheat, which dominated the wheat production, is mostly grown on the large slopes in the western part of the watershed.

Table 14. Crop area in the Hernád watershed

Crops	**Size, ha**
Tillage (plough) land	41000
Orchard	830
Grass land	26000
SUM	**67830**
Crops on ploughed land	**Size, ha**
Wheat	25000
Maize (corn)	4000
Sunflower	7000
Potato	600
Sugar-beat	1000
Rape	600
Lucern (alfalfa)	1800
Others	1000
SUM	**41000**

The winter wheat is planted in the autumn. The production is rotated, growing sugarbean, maize and winter wheat in sequence on the same fields.

Over the past few years the area that receives fertiliser is reduced drastically (see chap. 5.3.3). The grassland area has increased with 20.000 ha, and the total crop yield is more than halved.

5.2.2. Animal Husbandry

The state has encouraged the owners of larger husbandries to close down the activity. This has resulted in a 50% decrease in the animal husbandry. The dominating animals are cattle, pig, sheep, and poultry.

Table 15 and 16 show the number of animals in the total watershed, and where the major settlements are located.

Table 15. Total number of animals in the catchment area of Hernád.

	1993	1994
Cattle	6000	5200
Pigs	7000	6000
Sheep	6000	5000
Horses	NA	NA
Poultry	NA	NA

NA= Not available

Table 16. Number of animal husbandry in major settlements.

	cattle	sheep	poultry
Halmaj	1000	2000	20000
Encs	300		
Novajidrány	200		
Telkibánya	100		
Fulókércs		1000	
Gesztely	500		
Hernádneméti	300		
Hernádkak	50		
Böcs	300		
Sajóhidvég	200		

5.2.3. Agriculture practice

Manure storage

The total quantity of organic manure used on the fields is rather low because of the decreased rate of animal husbandry. The organic manure represents only 2-5% of the total fertiliser consumption, and is mostly spread on the tillage areas.

The storage facilities for manure are poorly developed. Where storage tanks exist they are very often leaking (soil tanks without sealing). The general picture is that the smaller animal husbandries do not have storage tanks at all and pump the manure directly into the field at any time of the year. This practices create large losses of nutrients, especially nitrogen.

For the larger husbandries, of which there is few left, the application periods are after harvest, before autumn tillage and in the early spring.

The application rate of organic manure is about 25-50 t/ha.

Ploughing

The soil is tilled every second year. One or two times each year, the upper topsoil is underlayed disking, following smoothing of the soil surface.

Heavy tillage is seldom, to reduce the erosion risk only the upper layer is ploughed.

The tillage is done mainly in the autumn. Spring tillage to reduce the erosion is not common. The argument is lack of time in the spring, and they do not consider erosion as a large problem especially over the last years when the precipitation has been very low (reduced from 550 mm to 400 mm per year)

Fertiliser use, and intensity

There are two main application periods for application of chemical fertiliser, early spring and after harvesting and in the middle of the autumn (just before tillage). In case of the spring wheat and barley, they only fertilise once.

The fertiliser is spread with the use of spreading machines.

The fertiliser consumption in the area have been reduced substantially over the last decade due to higher prices and the changed working conditions in the agricultural area. This is shown in Figure 9.

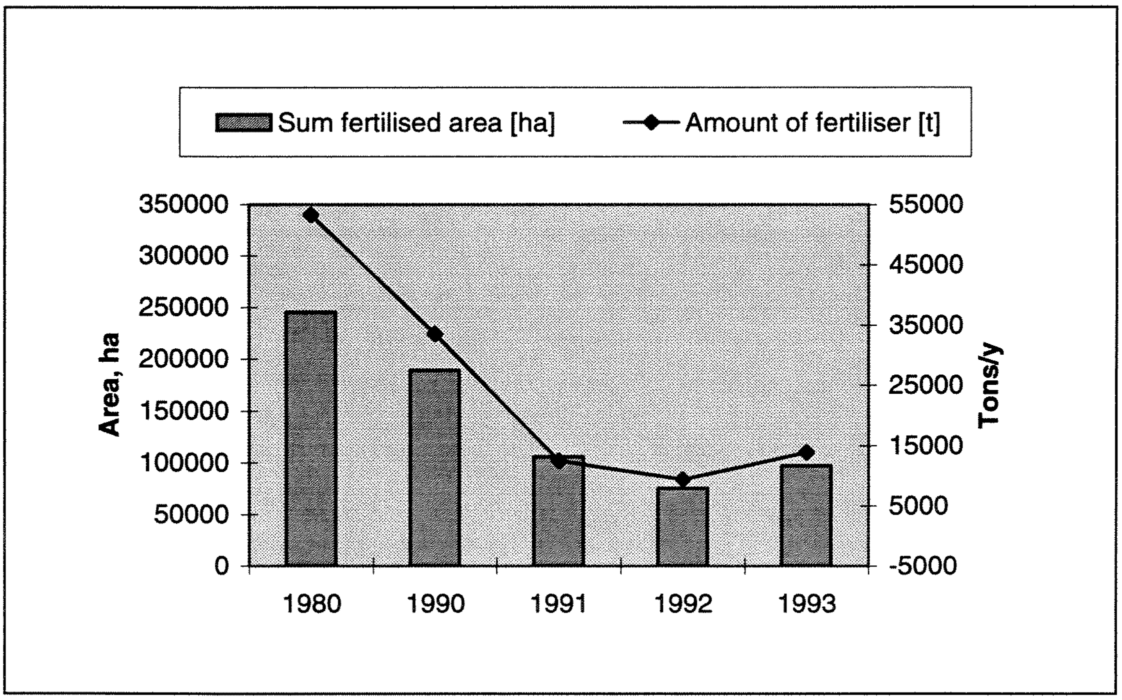

Figure 9. Fertilised area and amount (consumption) of fertiliser for the Borsod-Abauj-Zemplén County. Note: Not continuous x-axis.

Figure 9 shows a 60% decrease in fertilised area from 1980 to 1993, of which most of the reduction has took place from 1990 to 1993 (49%). For the consumption of fertiliser, the reduction is even more drastic, 74% from 1989 to 1990, of which 58% between 1990 and 1993.

The cultivation of Vineyard and Orchard in the region was almost reduced to zero in this period. The grass land area has increased at the same rate as the decrease of other plants, but only a small part of the grassland receives chemical fertiliser.

The balance in content between the nutrients in the fertiliser has been improved recently, e.g. is the relative proportion of phosphorus reduced from about 30% to 12% since 1980 while the nitrogen content has risen. Taking this into account, fertilising intensity has been reduced drastically to today's level of 26 kg N /ha and 8 kg P /ha (without manure) as mean numbers for tillage. This is low compared to Norway, Sweden and Germany, and very low compared to the Netherlands, Belgium and Denmark (OSPARCOM 1993). The fertilising statistics are not reported as pure N and P. In the above intensity calculation it is assumed that P is reported as P_2O_5 and N as NO_3.

The manure is only spread on about 5% of the tillage area. However, the intensity is high on these areas. Calculations based on animal numbers and specific production of N and P give an intensity of 224 kg N /ha and 21 kg P /ha, which is very high.

5.2.4. Load from area run-off and point pollution sources.

This section aims at quantifying the pollution load to local surface waters from agricultural activities in the catchment area. Data collection has been difficult because of the lack of recent statistics.

Some of the data was lacking, and parts of the calculation is based on using "best judgement".

Area run-off.

The contribution from the diffuse sources are often much larger than from the agricultural point sources.

To establish area specific run-off coefficients (kg/ha), it is necessary to have information about the following:

- crop type
- fertilisation intensity
- mechanical soil handling
- soil type
- slopes
- climatic conditions, e.g. precipitation
- run-off

For some of these elements the information is inadequate. The estimation of the run-off coefficients has therefore a rather high level of uncertainty.

For Norway and many other Western European countries there has been carried out a large number of studies of run-off from areas in different regions. Such empirically established run-off coefficients are unfortunately not established in the Hernád catchment area.

It is done a comparison of run-off coefficients from other East European regions, and with some regions in Norway that have several similarities (Table 17). The crop areas, especially in the western parts of Hernád, have long slopes which are susceptible to erosion. For the tillage area the coefficients for phosphorus will therefore be higher than the named East European regions in Table 17, which are predominantly flat areas.

Table 17. The average nutrient run-off coefficients for different agricultural areas. (From Berge et al. 1992, and Tjomsland and Bratli 1995.)

Region	Nitrogen run-off coefficient Kg N/ha year	Phosphorus run-off coefficient Kg P/ha year
St. Petersburg region	25	0.3
Estonnesia	20	0.2
Latvia	23	0.25
Lithuania	25	0.3
Kaliningrad region	19	0.2
Vistula catchment and Baltic	23	0.2
Coastal areas of Poland		
Odra River Basin	23	0.22
North German Coast		
Østfold county, Norway	32	0.99
Hedemark county, Norway	27	0.55

After an evaluation of previously used coefficients in other regions and differences in factors that influence the run-off, the mean average run-off coefficient for different crops was set in accordance with Table 18. This Table also shows the actual run-off of P and N for the different crops.

Table 18. Size mean average run-off coefficients and actual run-off from the different crop areas in Hernád.

Crops:	Size, ha	coeff.kgP/ha	coeff.KgN/ha	kgP	kgN
Tillage (plough) land	41000	0,4	28	16400	1148000
Orchard	830	0,3	20	249	16600
grass land	26000	0,2	6	5200	156000
SUM	**67830**			**21849**	**1320600**

To obtain the annual load of nutrients to the three recipient areas (Table 19), it is assumed that the relative distribution between the different crop types are the same in each of the different recipient areas.

Table 19. Annual nutrient load from agricultural areas within the different recipient areas.

	Crop area km^2	kgP	kgN
1. Border - Vizsoly	151	4866	294116
2. Vizsoly-Gesztely	444	14308	864818
3. Gesztely - mouth	83	2675	161666
SUM	678	21849	1320600

Point sources.

Agricultural point sources are connected especially to leakage from the following:

- Manure tanks
- Ensilaged hay
- Milking parlours

The former is assumed to be the major point source. It has been difficult to obtain information about ensilage and milk room, and we have therefore not tried to calculate inputs from these sources. In any case these sources are assumed to be minor.

Leakage from manure tanks, however, is a large problem. The old large collective farms had a reasonable way of storing the organic manure. The manure produced outside the growing season was collected in tanks and spread predominantly in the growing season. After the collapse of the large collective animal husbandries, smaller entities was created, and the total volume of animal husbandry also was reduced. As previously mentioned, many of the minor husbandries have earth tanks with large leakages, and some even lack storage possibilities completely. The manure are therefore spread onto the fields all year around.

The calculations of the leakage of manure to surface waters, are based on leakage coefficients from Norwegian tanks with large leakages and drainage. This means that 10% of the phosphorus and 12% of the nitrogen is lost (Table 20). This is a conservative estimate, taken into account that these cellars have concrete walls.

Table 20. Coefficients for nitrogen and phosphorus loss from manure storage's (Lundekvam and Berge 1989).

Category and condition of manure storages	Discharges into surface water recipients as % of stored manure	
	Nitrogen	Phosphorus
Tight storages:		
With drainage	0.5	0.15
Without drainage	0.4	0
*Storage with relatively small leakages		
With drainage	1.5	0.5
Without drainage	1.3	0.15
Storages with wooden doors (relatively large leakages)		
Cattle:		
With drainage	5.5	1.3
Without drainage	5.0	0.3
Pigs:		
With drainage	4.0	2.4
Without drainage	3.5	0.6
Storages without doors (extra large leakages)		
With drainage	12	10
Without drainage	10	2.5

The total production of organic manure is calculated on the basis of P an N production from each type of animals (Table 21). It is assumed that the animals are kept in cowshed 6 months of the year.

Table 21. Animal husbandries, number, production of N and P and leakage.

	Number	kgP/animal * year	kgN/ind. *year	kg prod. P/year	kg prod. N/year	kg P leaked/year	kg N leaked/year
Cattle	5200	12,6	82	32760	213200	3276	25584
Pigs	6000	5,5	16	16500	48000	1650	5760
Sheep	5000	1,9	13	4750	32500	475	3900
						5401	**35244**

The larger animal husbandries that is reported one by one, are only a small part the total. The major part of the animals is therefore divided between the three recipient areas after the crop area size of each recipient area, and is in Table 22 reported as unspecified.

Table 22. Leakage of phosphorous and nitrogen from organic manure in the different recipient areas.

	Recipient Area	Tot P	Tot-P sum recip. area	Tot-N	Tot-N sum recip. area
Telkibánya	Upstream Hidasnémeti	63		492	
Novajidrány	Hidasnémeti -Vizsoly	126		984	
Unspecified	Hidasnémeti -Vizsoly	683	*872*	3940	*5415*
Halmaj	Vizsoly-Gesztely	1010		7180	
Encs	Vizsoly-Gesztely	189		1476	
Fulókércs	Vizsoly-Gesztely	95		780	
Gesztely	Vizsoly-Gesztely	315		2460	
Unspecified	Vizsoly-Gesztely	2009	*3618*	11585	*23481*
Hernádnémeti	Gesztely -Böcs	189		1476	
Hernádkak	Gesztely -Böcs	31,5		246	
Böcs	Gesztely -Böcs	189		1476	
Sajóhidvég	Downstream Böcs	126		984	
Unspecified	Gesztely-Böcs	376	*911*	2166	*6347*
SUM		**5401**		**35244**	

5.3. Background load

5.3.1. Forest area.

There are large areas that are forested in the catchment area, especially in the east and north-east mountainous regions. As shown in Table 23 about 20% (200 km^2) of the total area is forested. The run-off coefficients are estimated on the basis of the deposition, soil type and precipitation in the area, see under 5.3.2 area.

Table 23. Run-off coefficients and load from forest areas.

Recipient area	Forest area	coeff. kgP/km^2	coeff. KgN/km^2	kgP	kgN
1. Border - Vizsoly	103	12	170	1236	17510
2. Vizsoly - Gesztely	86	12	170	1032	14620
3. Gesztely - mouth	11	12	170	132	1870
SUM	**200**			**2400**	**34000**

5.3.2. "Other" area.

The areas that are not forest areas and crop areas are called “other” areas. This includes:

- open water and riverbanks
- roads
- villages

There is no available information about the size of the different types of areas in the catchment, and it is also difficult to obtain this from planimetration. It is however assumed that the villages and roads comprise the major area.

5.3.2.1. Atmospheric deposition on open water.

The atmospheric deposition on open water is often relatively large (high coefficients). Figures on deposition are available from Kescemet (Schaug et al 1993). The figures for the year 1991 there was measured 497 NH_4/km^2 and 360 NO_3/km^2. This gives 857 kg N/km^2 as Tot-N when dry deposition is excluded, as it is neglectable on open water (Tørseth and Pedersen 1994).

There are no specific atmospheric deposition values for phosphorus, available in Hungary. This deposition is not often measured, and the reported values from literature vary much, from less than 4 to more than 100 kg Tot-P pr km^2 and year. The phosphorous is to a large extent bound to particles, and Norwegian studies show that about 50 % of the Total-P is PO_4-P (Holtan et al. 1995). Studies from the Czech republic suggest a value of 60 kg/km^2 and year, which may be applicable also for the Hernad area (Dagestad et al. 1995).

5.3.2.2. Pollution from roads and villages.

The coefficients for this type of pollution will depend on population density, precipitation, drainage system etc.

In more city-like areas, the run-off coefficients are higher. This is because of the higher rate of dense areas such as roofs and roads. The high concentration of especially nitrogen in the precipitation will then be maintained.

The villages have a rather small percentage of dense areas, and the coefficients are therefore lower, 30-40 kg Tot-P and 250-350 kg Tot-N per km^2 and year.

5.3.2.3. Run-off coefficients and loads from "Other area".

Mean run-off coefficients from deposition on open water, riverbanks, roads and villages are determined for the Hernád on the basis of the specific coefficients stated in the previous sections and with the assumption that the village area comprises most of the area. This is shown in table 24.

Table 24. Mean run-off coefficients and actual run-off for "Other area".

Recipient area	Other area	coeff.kgP/km^2	coeff.KgN/km^2	kgP	kgN
1. Border - Vizsoly	39	40	400	1560	15600
2. Vizsoly-Gesztely	83	40	400	3320	33200
3. Gesztely-mouth	15	40	400	600	6000
SUM	**137**			**5480**	**54800**

5.4. Water Pollution Budget

5.4.1. Sources

Table 25 - 27 give the sources of different kinds of pollution parameters both inside and outside Hungary. The pollution loads from Slovakia are calculated on the basis of flow and chemical substances at Hidasnemeti, close to the border of Slovakia. It is evident that for nearly all the pollution substances the loads from Slovakia are dominant. The Hungarian contribution of BOD and Tot-P is about 20 % of the total. For heavy metals the Hungarian contribution is even less. Only for nitrogen the Hungarian part is large, 53 % of the total contribution. This is mostly due to the agricultural activities on the Hungarian side (figure 10).

Table 25. Total pollution loads (ton/y)

	Border - Vizsoly					Vizsoly - Gesztely					Gesztely - mouth				
	BOD	COD	SS	Tot-P	Tot-N	BOD[1)]	COD	SS	Tot-P	Tot-N	BOD1[)]	COD	SS	Tot-P	Tot-N
Slovakia	5778			329	2535										
Agriculture				5,7	300				17,9	888				3,6	168
Forest				1,2	18				1,0	15				0,1	1,9
Other area				1,6	16				3,3	33				0,6	6,0
Mun.+Industry	187.5	468.8	158	10.2	49	618.7	1546.8	522.8	35.2	170	215.7	539.3	184.6	11.8	56.5
Pankl-Hofmann												0.5	1.5		0.5
SUM	5966	469	158	348	2918	619	1547	523	57	1106	216	540	186	16	233

Table 26. Pollution load (kg/y)

	Border - Vizsoly					Gesztely - mouth				
	Cd	Hg	Zn	Pb	Cu	Cd	Hg	Zn	Pb	Cu
Slovakia	700	123	62000	6000	8000					
Pankl-Hofmann						0.5	-	490	0	0.5

Table 27. Total pollution load (ton/y)

	BOD	COD	SS	Tot-P	Tot-N
Slovakia	5778			329	2535
Agriculture				27	1356
Mun.+Industry[1)]	1022	2556	867	57	275

1) Incl. Pankl-Hofmann

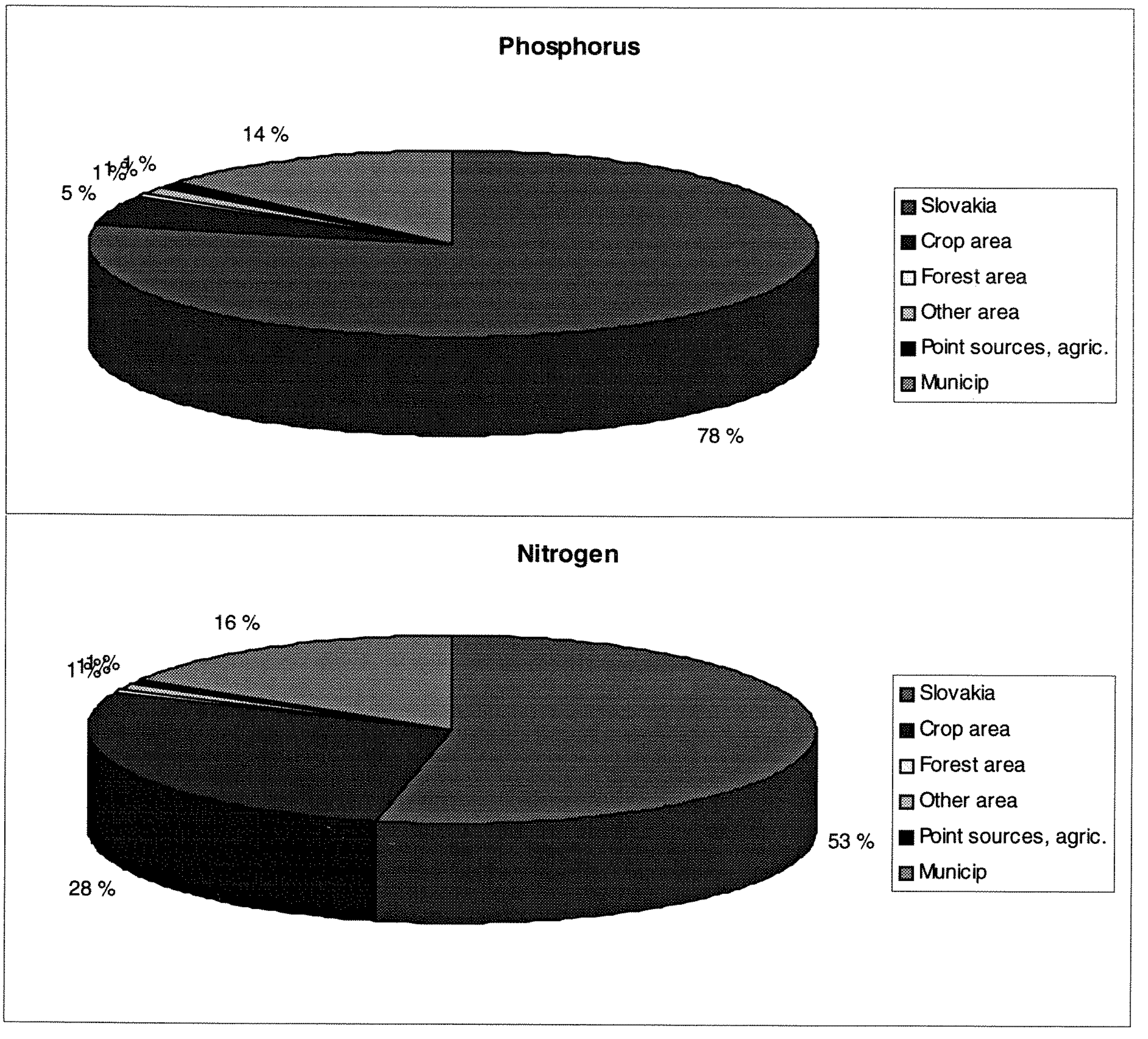

Figure 10. Phosphorus and nitrogen budgets for total inputs from Slovakia and Hungary. The latter inputs is partitioned on main sources.

5.4.2. Pollution transport in rivers

The pollution transport in the river is measured at Hidasnemeti and at Gesztely on the basis of mean concentrations and flow over the last four years. Not only the water quality (concentrations) is improving downstream in Hernád at the Hungarian side of the border, also the *transport* at Gesztely is lower (except for nitrogen) than the transport at Hidasnemeti, close to the border to Slovakia (table 28). This means that the selfpurification in the river system is large. However the self-purification in the different river profiles is not quantified in this study.

Table 28. Pollution transport in tons pr. year, measured at two stations in the river.

		BOD t/y	Tot-P t/y	$N-NH_4$ t/y	$N-NO_2$ t/y	$N-NO_3$ t/y	Tot-N t/y	Cd t/y	Hg t/y	Zn t/y	Pb t/y	Cu t/y
1	Hidasnemeti	5778	329	748	82	1783	2535	0.70	0.123	62	6.0	8.0
3	Gesztely	5190	306	512	52	2339	2904	0.54	0.109	54	8.3	6.1

6. Need for pollution abatement

6.1. Objectives

6.1.1. Criteria for setting Water Quality objectives

Water quality objectives for a recipient must be based on the pollution effect both on human health and ecology. Since environmental objectives involve choices (according to human health, ecology and even to other important issues a community is obligated to solve) the objectives for water quality should be related to, or reflect, the user interests in the recipient area. Each user interest will require a certain water quality with respect to human health, to ecology, and so forth.

The water quality objectives must also be in accordance with environmental legislation and standards, and external factors such as; governmental obligations, EU requirements, common environmental plans and international conventions.

Finally, there must be a balance between the water quality objectives and the possibility to reach these goals which depends on technical opportunities to reduce the pollution, the costs for the investment plans and the level of natural water quality.

The effluent standards will in some cases decide the level of minimum treatment, even if the pollution source is not considered as a problem to the recipient.

<u>User interests</u>

Periods with strict economical prioritisation will also influence the environmental sector, and it is important to use the rather limited resources in areas with the most serious water quality problems and seek cost-efficient solutions. The most serious problems are more obvious in areas where there are competitive user interests, and the user interests are suffering from a bad water quality.

In order to put the user interests in focus, several steps have to be considered before deciding on the need for pollution abatement:

- Prioritising of the user interests and planned future use.
  This can be a political question especially concerning the future use.

- Selection of a water quality for every pollution parameter, which will satisfy today's prioritised user interests or the future use. *The preliminary Hungarian criteria for user interests can be used.*

- Identify the water quality parameters which have to be improved in order to reach the goals set.

- Calculate the need for reduction of "problem" parameters.

Ecology

The water quality objectives can also be related to a certain ecological status. The procedure will be the same. It is necessary to determine the wanted ecological situation (objective) classified according to the Hungarian Classification system.

6.1.2. Proposed water quality objectives

Portioning of Hernád in recipient area:

Hernád river has been divided into three recipient areas;

1. Border-Vizsoly
2. Vizsoly- Gesztely
3. Gesztely-mouth

Already existing water quality monitoring stations and the user interests (homogenous user interests within one area) have decided this sectioning.

In addition, each tributary represent a recipient area.

Objectives for the recipient area

5 alternative water quality objectives for the water quality in the catchment to Hernád river have been proposed(see Table 29). In this study the user interests and their need for a certain local water quality has been guiding factors in setting the water quality objectives and calculating the need for pollution abatement (objective 1-3). The present user interests have been described as follows:

Border-Vizsoly:	The river from the border to Vizsoly is mainly used for irrigation.
Vizsoly-Gesztely:	The river from Vizsoly to Gesztely is also mainly used for irrigation, some drinking water interests.
Gesztely-mouth:	There are drinking water interests in the lowest part of the river.

In the tributaries the dominant user interest are irrigation and water supply for husbandry.

Table 29. Alternative objectives for the water quality in Hernád and its tributaries

	Objective 1				Objective 2				Objective 3				Objective 4				Objective 5			
	Water quality	Drinking Water	Irrigation	Animal Husbandry	Water quality	Drinking Water	Irrigation	Animal Husbandry	Water quality	Drinking Water	Irrigation	Animal Husbandry	Water quality	Drinking Water	Irrigation	Animal Husbandry	Water quality	Drinking Water	Irrigation	Animal Husbandry
Border-Vizsoly													III				II			
Vizsoly-Gesztely													II				II			
Gesztely-Mouth													II				II			
Tributaries													III				III			

Objective 1: Objectives to satisfy today's user interests
Objective 2: Objectives if drinking water quality should be provided up to Vizsoly
Objective 3: Objectives if drinking water quality should be provided in the whole river
Objective 4 and 5: Objectives to meet a certain water quality, according to the criteria's.

The preliminary proposal for water quality criteria's for user interests, class I "Preferred water quality" has been used to set the limits according to the objectives 1-3 in table 29. The status in the recipient profiles and the objectives is shown in table A5 in the appendix.

6.2. Need for pollution abatement

6.2.1. Method(s) used

The difference between the water quality in the river today and the objectives set for water quality in the different parts of the catchment area for the future provides the basis for the calculation of reduction loads.

The water quality is classified according to the C_{90} value. For some parameters the worst water quality occurs at the time of low flows, whilst other parameters follow the variations in water flow.

In order to find an appropriate way to calculate need for reduction for different pollution parameters based on the critical values (C_{90}), the statistical C_{90} value for the data in 1989-1994 is calculated and compared with the average concentrations of the samples (see the formula used for average concentrations).

$$C_{average} = \frac{\sum_{i=1}^{12} c_i * q_i}{\sum_{i=1}^{12} q_i}$$

For those stations where there exist monitoring data over a period of time, the real f values=$C_{average}/C_{90}$ is used to calculate the need for reduction according to the formula below.

$$M_{x,reduction} = [C_{90,today} - C_{90,objective}] * f_x * Q_{180}$$

For the other stations where monitoring data are scarce or where water quality data do not exist the average f value for the water quality stations are used (see Table 30)

Table 30. Relationship between $C_{average}/C_{90}$, f-values.

Parameter	Hidasnémeti	Gesztely	f.average including data from tributaries
BOD_5	0.8	0.8	0.8
$N\text{-}NH_4$	0.2	0.2	0.4
$N\text{-}NO_3$	0.5	0.6	0.6
Tot-N	0.33	0.4	0.4
Tot-P	1	0.22	0.4
Cd	0.4	0.4	0.3
Hg	0.7	0.8	0.8
Zn	0.7	0.7	0.6
Pb	0.4	0.5	0.3
Cu	0.6	0.7	0.6

6.2.2 Reduction in load

Table 31 shows the need for reduction in load according to different objectives. The chosen water quality objectives for the different parameters are marked.

Table 31. Need for reduction in loads in different river profiles and tributaries.

	Profile				Objective 1 (Tonnes / Year)							Objective 1 (Kg / Year)				
Nr.		BOD	COD - Mn	N-NH4	N-NO2	N-NO3	P-PO4	Tot-P	Mn	Fe	Hg	Cd	Ni	Zn	Pb	Cu
1	Hidasnémeti			1233	102				72	745			1035,5			
2	Vizsoly															
3	Gesztely			794	40				67	597			1499,0			
4	Mounth															
5	Bélus - creek			3,6												
6	Gönci - creek			0,3												
7	Vadász - creek			4,5												
8	Hernád diversion canal			0,2												
9	Bársonyos canal A			0,0												
10	Bársonyos canal B			1,2						0,1		0,9	0,5			
Nr.	Profile				Objective 2							Objective 2				
		BOD	COD - Mn	N-NH4	N-NO2	N-NO3	P-PO4	Tot-P	Mn	Fe						
1	Hidasnémeti			1233	102				72	745			1035,5			
2	Vizsoly															
3	Gesztely	3222		797	40		78	367	166	1142		339,2	1499,0			
4	Mounth															
5	Bélus - creek			3,6												
6	Gönci - creek			0,3												
7	Vadász - creek			4,5												
8	Hernád diversion canal			0,2												
9	Bársonyos canal A			0,0												
10	Bársonyos canal B			1,2						0,1		0,9	0,5			
Nr.	Profile				Objective 3							Objective 3				
		BOD	COD - Mn	N-NH4	N-NO2	N-NO3	P-PO4	Tot-P	Mn	Fe						
1	Hidasnémeti	3769		1236	102		98		167	1270		506,0	1035,5			
2	Vizsoly															
3	Gesztely	3222		797	40		78	367	166	1142		339,2	1499,0			
4	Mounth															
5	Bélus - creek		10,8	3,6												
6	Gönci - creek		0,7	0,3												
7	Vadász - creek		6,5	4,5												
8	Hernád diversion canal		0,6	0,2												
9	Bársonyos canal A		0,1	0,0												
10	Bársonyos canal B			1,2						0,1		0,9	0,5			
Nr.	Profile				Objective 4							Objective 4				
		BOD	COD - Mn	N-NH4	N-NO2	N-NO3	P-PO4	Tot-P	Mn	Fe						
1	Hidasnémeti	1820		1089	96		137	235	135	1211	49,3	506,0		38426,0	1520,2	4272,3
2	Vizsoly															
3	Gesztely	1195		644	34		119	839	133	1081	4,5	339,2		24207,7	1362,0	1950,5
4	Mounth															
5	Bélus - creek		11,0	3,5		4,7										
6	Gönci - creek		0,7	0,3		0,0										
7	Vadász - creek		6,7	4,5		3,1										
8	Hernád diversion canal		0,7	0,2		0,2										
9	Bársonyos canal A		0,1	0,0		0,1										
10	Bársonyos canal B			1,1		0,1				0,2		0,9	0,4	0,1		0,7
Nr.	Profile				Objective 5							Objective 5				
		BOD	COD - Mn	N-NH4	N-NO2	N-NO3	P-PO4	Tot-P	Mn	Fe						
1	Hidasnémeti	3119	1724	1185	102	1401	146	265	167	1270	111,7	632,5	1916,1	53205,2	5451,6	6434,4
2	Vizsoly															
3	Gesztely	2546	959	744	40	1629	128	870	166	1142	69,4	470,7	2414,2	39567,9	5448,0	4197,6
4	Mounth															
5	Bélus - creek		11,0	3,5		4,7										
6	Gönci - creek		0,7	0,3		0,0										
7	Vadász - creek		6,7	4,5		3,1										
8	Hernád diversion canal		0,7	0,2		0,2										
9	Bársonyos canal A		0,1	0,0		0,1										
10	Bársonyos canal B			1,1		0,1				0,2		0,9	0,4	0,1		0,7

7. Methods for calculating cost-effectiveness and review of technical measures

7.1. Costs, effects and benefits

Some measures have large investment costs, but relative moderate annual operational and maintenance costs (O&M costs). This is often the case for measures in the municipal and industrial sector. For other measures, e.g. in the agricultural sector, most of the costs are connected with annual O&M costs.

In order to compare measures within several sectors, total annual costs have been estimated. They are based on discounted investment costs and the running costs of operation and maintenance. A discount rate of 4% has been used throughout the study. The economic life span of measures will vary between measures, but for most of the measures it is considered to be 20 years.

7.1.1. Estimation of annual costs

To calculate the investments annual capital cost, the investment cost has to be multiplied with the factor of annuality, with given life-span for the measure and interest rate. If we add/subtract the annual O&M costs/gain, we get the annual cost. Reduced costs because of implemented measures is to be subtracted. The calculation of the total annual cost can therefore be described as:

Total annual cost = A * (investment cost) +/- changes in annual O&M costs +/- changes in other costs

A = the annuality factor, defined as: $A = r\,(1+r)^t / (1+r)^t - 1$,
where
r = 0,04 when the interest is 4%
t = economical life span

7.1.2. Calculation of effects, cost-effectiveness criteria and benefits

The effect of the measures is calculated as the reduction in input to surface waters per year of phosphorus and nitrogen.

The criteria of cost-effectiveness for ranging of the measures will therefore be:

$$\text{Cost - effectiveness} = \frac{\text{total annual costs in 1000 NOK}}{\text{red. kg P or N pa.}} \quad \text{(+ any additional effects/benefits)}$$

It is often usual to take the bio-availability of nutrients into account when calculating the effect. This is not done here because of the lack of information on bioavalibility in Hungarian waters. If bio-availability was to be taken into consideration it should be calculated into the formula under the division bar as a factor from 0-1, showing 0-100% bio-availability for each type of effluent.

Additional benefits include measures that solve more than one problem. An example is agricultural measures that not only reduce run-off of phosphorus, but also reduces the load of suspended solids to the river. Another example is measures in the municipal sector that reduce phosphorus, organic matter and bacteria inputs.

This is not a true cost/benefit analysis. In order to find the true benefit, peoples' judgement of the benefit, valued in money, has to be determined. There are several methods for finding the economic benefit, but most methods just estimates a section or part of the total benefit. To estimate the total benefit it is common to go through an analysis for finding the peoples willingness to pay (Contingent Valuation Method), including e.g. personal interviews.

7.2. Municipal Sources and Industry

7.2.1. Hot-Spots

Based on the previous sections and the need for reduction of organic matter, phosphorus and nitrogen it is obvious that as much as possible of the pollution from municipalities and industries needs to be reduced.

There are however some municipalities which can be regarded as "Hot-spots" because of their size and their location. Table 30 shows 23 of the 71 municipalities which constitute approximately 75% of the total pollution and which are located very close to Hernád river and thereby directly affect the water quality (see Figures 1 and 2, and Table 32).

Table 32. Hot spots for abatement in the municipal sector (P.e. = personal equivalents).

Municipality	Pe Mun.	Pe Mun+ind	Area km²	Rural Sewage m^3/d				Public sewage m^3/d				Total loads ton/year,			
				% Rural	Pe	Q consump	Q dim	% Public	Pe	Q dom.	Q ind.	BOD	SS	Tot-P	Tot-N
Alsóvadász	1477	1477	2291	100	1477	148	295					24	20	1	6
Aszaló	1960	1960	2536	100	1960	196	392					31	27	2	8
Berzék	933	933	1060	100	933	93	187					15	13	1	4
Böcs	2643	2647	2432	93	2452	245	490	7	191	281	1	40	34	2	11
Encs	6663	7544	3113	59	3932	393	786	41	2731	310	176	92	73	6	30
Felsődobsza	914	914	1519	100	914	91	183					15	13	1	4
Forró	2239	2239	1901	100	2239	224	448					36	31	2	9
Gesztely	2753	2753	2882	100	2753	275	551					44	38	2	11
Gönc	2378	2538	3726	95	2260	226	452	5	118	17	32	42	34	2	11
Göncruszka	714	714	1669	100	714	71	143					11	10	1	3
Halmaj	1761	1761	1259	100	1761	176	352					28	24	2	7
Hernádkak	1036	1036	1090	100	1036	104	207					17	14	1	4
Hernádnémeti	3598	3598	2876	100	3598	360	720					57	49	3	15
Hernádvécse	851	851	1689	100	851	85	170					14	12	1	4
Hidasnémeti	1167	1690	1618	97	1135	114	227	3	32	9	105	23	18	1	6
Homrogd	987	987	1343	100	987	99	197					16	14	1	4
Ináncs	1167	1167	1095	100	1167	117	233					19	16	1	5
Novajidrány	1399	1399	1431	100	1399	140	280					22	19	1	6
Onga	4419	4419	3150	100	4419	442	884					71	60	4	18
Sajóhídvég	987	987	1345	100	987	99	197					16	14	1	4
Szalaszend	1129	1129	1822	100	1129	113	226					18	15	1	5
Szikszó	6110	7048	3620	92	5651	565	1130	8	459	78	188	101	84	6	29
Vizsoly	929	929	1844	100	929	93	186					15	13	1	4
SUM, 71	64319	64319	101718	95	60789	6079	12158	5	3530	695	501	1022	865	57	275
Sum 23	48214	50720	47311	93	44684	4468	8937	7	3530	695	501	765	645	43	208
SUM 23/sum71 (%)	75		47		74	74	74		100	100	100	75	75	76	76

7.2.2. Technical measures

Specification of treatment technology

To obtain reduction in the input of organic matter, nitrogen and phosphorus, advanced treatment technology needs to be introduced both for phosphorus and nitrogen removal. The existing plants should be upgraded in order to obtain the efficiencies in Table 33.

Table 33. Minimum treatment efficiency at the proposed treatment plants (%).

Plant	Description	BOD	SS	Tot-P	Tot-N
B&C+N	Biological/chemical plant with N removal in an activated sludge process	90	95	90	70

The KMT moving bed biological process provided by Kaldnes Miljøteknologi is based on the biofilm principle, but utilises both the advantages of the activated sludge and biofilm processes. The KMT process when installed with chemical precipitation, gives substantial reduction of organic matter, nitrogen and phosphorus inputs, and guarantees the efficiency-rates in Table 33.

The KMT process has been specialised for small and medium-sized waste water treatment plants with capacities ranging from 5-300 000 person equivalents, to serve single dwellings, villages or smaller cities. The plants can be fully automated, and larger populations or areas can be served by several plants, co-ordinated through an operation centre. In these operation centres information technology are used to control processes, monitoring and maintenance.

Strategy for Hernád

Each municipality in Hernád can treat their waste water and use local recipients for the outlets from the plants, or inter municipal co-operation can be established so that only a limited number of waste water treatment plants need to be build.

In many cases inter municipal co-operation will reduce the environmental impact and the costs, but this will depend on the increased transportation costs for sewage (length of sewage system, the need for installing pumps etc.), reduced investment costs at the WWTP and reduced operation and maintenance costs. A prerequisite for collection of sewage from many communities is that recipients which can handle the increased point outlets from the waste water treatment plant.

In this study these 2 main alternatives have been studied, and the final recommendations is based on the total capitalised costs of the effects of the measures on the water quality.

Alternative 1: Inter municipal co-operation for handling of waste water from the "Hot-spots"
Alternative 2: Individual waste water treatment plants for each of the 23 "Hot-spots"

The KMT process has been used in both alternatives to calculate pollution loads after measures and the costs for the measures. The present population and the present loads from the industry have been used for the calculations.

Based on the location of the municipal "Hot spots" and the topography in the basin, it has been proposed in alternative 1 to establish 7 waste water treatment plants ranging from about 2000-16.000 pe (see Table 34). Tornyosnémeti and Garadna have been included in alternative 1 in addition to the 23 "Hot-spots".

Alternative 2 includes waste water treatment plants in each of the 23 municipalities, Tornyosnémeti and Garadna are not included (see Table 34).

The present and calculated loads to the existing wastewater treatment plants, if these are going to be used for the respective "treatment district", are shown in Table 34 for both alternatives. The existing loads and treatment facilities at the waste water treatment plants are also described earlier in chapter 5.

Table 34. Capacity at existing waste water treatment plants

Municipality/ plant	Treatment			Present load	Calculated load, Qdim, to WWTP after sanitation and capacity/Qdim(%) alternative 1	Calculated load to WWTP after sanitation and capacity/Qdim(%) alternative 2
	Mech. [%]	Biol. [%]	Capacity m^3/d	m^3/d	m^3/d (%)	m^3/d
Böcs WWTP		100	179	282	3518 (5%)	772 (23%)
Encs WWTP		100	1000	486	1498 (67%)	1272 (79%)
Gönc WWTP	100		80	49	644 (12%)	501 (16%)
Hidasnémeti, WWTP	49	51		114	470	341
Szikszó, WWTP		100	452	266	2627 (17%)	1396 (32%)

Spesific load =200ltr/p.e day

Table 34 shows that the existing WWTP only can be used to some extent. The rehabilitation of the existing waste water treatment plants are described below and in Table 35 for both alternatives.

Hidasnémeti;

The treatment plant in Hidasneméti, is receiving both domestic and industrial waste water.

The biological/mechanical waste water treatment plant needs to be upgraded to fulfil the requirements. The existing WWTP will after the sanitation for both alternatives be heavily overloaded, and it is assumed that there will be no savings from upgrading of the existing one and building an additional treatment plant, compared to building a new one. It is also more efficient from an operation and maintenance point of view to build a new treatment plant treating all waste water within this "treatment district". It has also been assumed that the existing building is to small to be used for the new process equipment.

Gönc:

The mechanical treatment plant in Gönc needs to be upgraded, but is in both alternatives, it is much to small to handle the waste water after sanitation.

It has been suggested to close down the existing plant and build a new treatment plant for both alternatives. In alternative 1 it is suggested that this treatment plant should be located in Göncruszka, and the waste water from Gönc should be transferred to Göncruszka by gravity.
The old waste water treatment plant building will probably be to small also for alternative 2. The building costs have been included in both alternatives.

Encs;

The biological waste water treatment plant in Encs has a relatively large capacity compared to the calculated loads after sanitation. The treatment plant needs to be upgraded from a highloaded biological WWTP to a low loaded biological WWTP with nitrogen removal. It can be questioned whether the old one is in good condition and easily can be rebuilt, or if it is more cost-efficient to install new process equipment. A more detailed cost analysis needs to be undertaken before the final decisions are made.

The cost calculations are based on new process equipment, and the assumption that the old waste water treatment building is kept.

Szikszó

The capacity at the municipal treatment plant at Szikszó is to small. The cost calculations are based on installation of new process equipment. It is however assumed that the old building can be used for alternative 2, but costs for a new building must be included for alternative 1.

Böcs

The biological waste water treatment plant is to small to handle the waste water after sanitation. The cost calculations are based on new process equipment.

In alternative 1, the waste water treatment plant should be located downstream in the "waste water treatment district", in Sajóhídvég, to avoid pumping of waste water, if possible. It is also proposed to transfer the outlet from the waste water treatment plant to Sajó river which has a larger recipient capacity.

Table 35. Alternatives for waste water treatment

Loc. of WWTP	Municipalities	P.e. Domestic	P.e. Industry + Industry	Qdim rural (m^3/d)	Q Existing (m^3/d)	Q total (m^3/d)
Hidasnémeti	Hidasnémeti	1167	1690	227	114	341
	Tornyosnémeti	647	647	129		129
Qdim, WWTP		**1814**	**2337**			**470**
Göncruszka	Göncruszka	714	714	143		143
	Gönc	2378	2538	452	49	501
Qdim, WWTP		**3092**	**3252**	**595**	**49**	**644**
Vizsoly	Vizsoly	929	929	186		186
	Hernádvécse	851	851	170		170
	Garadna	425	425	85		85
	Novajidrány	1399	1399	280		280
Qdim, WWTP		**3604**	**3604**	**721**		**721**
Encs	Encs	6663	7544	786	486	1272
	Szalaszend	1129	1129	226		226
Qdim, WWTP		**7792**	**8673**	**1012**	**486**	**1498**
Felsôdobsza	Felsôdobsza	914	914	183		183
	Forro	2239	2239	448		448
	Ináncs	1167	1167	233		233
Qdim, WWTP		**4320**	**4320**	**864**		**864**
Szikszó	Szikszó	6110	7048	1130	266	1396
	Homrogd	987	987	197		197
	Alsóvadász	1477	1477	295		295
	Aszaló	1960	1960	392		392
	Halmaj	1761	1761	347		
Qdim, WWTP		**12295**	**13233**	**2361**	**266**	**2627**
Sajóhídvég	Sajóhídvég	987	987	197		197
	Onga	4419	4419	884		884
	Gesztely	2753	2753	551		551
	Hernádkak	1036	1036	207		207
	Hernádnémeti	3598	3598	720		720
	Böcs	2643	2647	490	282	772
	Berzék	933	933	187		187
Qdim, WWTP		**16369**	**16373**	**3236**		**3518**

The reduction in load after the proposed measures are calculated in Table 36 for both alternatives.

Table 36. Reduction in loads after treatment.

Municipalities	P..e. corr.	Qtotal m³/d	Load, before reduction, ton/year BOD	SS	Tot-P	Tot-N	Load, after, reduction ton/year BOD	SS	Tot-P	Tot-N	Reduction, ton/year BOD	SS	Tot-P	Tot-N
Hidasnémeti	1690	341	22.5	18.2	1.3	6.1	3.9	1.9	0.2	2.2	18.7	16.2	1.1	3.9
Tornyosnémeti[1)]	647	129	10.3	8.9	0.6	2.7	1.5	0.7	0.1	0.9	8.8	8.2	0.5	1.8
	2337	**470**	**32.8**	**27.1**	**1.9**	**8.8**	**5.3**	**2.7**	**0.2**	**3.1**	**27.5**	**24.4**	**1.6**	**5.7**
Göncruszka	714	143	11.4	9.8	0.6	3.0	1.6	0.8	0.1	0.9	9.8	9.0	0.6	2.0
Gönc	2538	501	41.6	34.1	2.2	10.7	5.8	2.9	0.2	3.3	35.8	31.2	2.0	7.3
	3252	**644**	**53.0**	**43.8**	**2.8**	**13.7**	**7.4**	**3.7**	**0.3**	**4.3**	**45.6**	**40.1**	**2.5**	**9.4**
Vizsoly	929	186	14.8	12.7	0.8	3.9	2.1	1.1	0.1	1.2	12.7	11.7	0.7	2.6
Hernádvécse	851	170	13.6	11.6	0.7	3.5	1.9	1.0	0.1	1.1	11.6	10.7	0.7	2.4
Garadna[1)]	425	85	6.8	5.8	0.4	1.8	1.0	0.5	0.0	0.6	5.8	5.3	0.4	1.2
Novajidrány	1399	280	22.3	19.1	1.2	5.8	3.2	1.6	0.1	1.8	19.1	17.6	1.1	4.0
	3604	**721**	**57.6**	**49.3**	**3.2**	**15.0**	**8.2**	**4.1**	**0.3**	**4.7**	**49.3**	**45.2**	**2.8**	**10.3**
Encs	7544	1272	92.1	73.4	6.1	30.4	17.2	8.6	0.7	9.9	74.9	64.8	5.5	20.5
Szalaszend	1129	226	18.0	15.5	1.0	4.7	2.6	1.3	0.1	1.5	15.5	14.2	0.9	3.2
	8673	**1498**	**110.1**	**88.8**	**7.1**	**35.1**	**19.8**	**9.9**	**0.8**	**11.4**	**90.4**	**78.9**	**6.3**	**23.7**
Felsôdobsza	914	183	14.6	12.5	0.8	3.8	2.1	1.0	0.1	1.2	12.5	11.5	0.7	2.6
Forro	2239	448	35.8	30.6	1.9	9.3	5.1	2.6	0.2	2.9	30.6	28.1	1.7	6.4
Ináncs	1167	233	18.6	16.0	1.0	4.9	2.7	1.3	0.1	1.5	16.0	14.6	0.9	3.3
	4320	**864**	**69.0**	**59.1**	**3.7**	**18.0**	**9.9**	**4.9**	**0.4**	**5.7**	**59.1**	**54.2**	**3.4**	**12.3**
Szikszó	7048	1396	101.0	84.5	5.9	28.7	16.1	8.0	0.6	9.3	84.9	76.5	5.3	19.4
Homrogd	987	197	15.8	13.5	0.9	4.1	2.3	1.1	0.1	1.3	13.5	12.4	0.8	2.8
Alsóvadász	1477	295	23.6	20.2	1.3	6.1	3.4	1.7	0.1	1.9	20.2	18.5	1.1	4.2
Aszaló	1960	392	31.3	26.8	1.7	8.2	4.5	2.2	0.2	2.6	26.8	24.6	1.5	5.6
Halmaj	1761	347	28.1	24.1	1.5	7.3	4.0	2.0	0.2	2.3	24.1	22.1	1.4	5.0
	13233	**2627**	**199.7**	**169.2**	**11.3**	**54.4**	**30.2**	**15.1**	**1.2**	**17.4**	**169.5**	**154.1**	**10.1**	**37.0**
Sajóhídvég	987	197	15.8	13.5	0.9	4.1	2.3	1.1	0.1	1.3	13.5	12.4	0.8	2.8
Onga	4419	884	70.6	60.5	3.8	18.4	10.1	5.0	0.4	5.8	60.5	55.4	3.4	12.6
Gesztely	2753	551	44.0	37.7	2.4	11.5	6.3	3.1	0.3	3.6	37.7	34.5	2.1	7.8
Hernádkak	1036	207	16.5	14.2	0.9	4.3	2.4	1.2	0.1	1.4	14.2	13.0	0.8	2.9
Hernádnémeti	3598	720	57.5	49.2	3.1	15.0	8.2	4.1	0.3	4.7	49.2	45.1	2.8	10.2
Böcs	2647	772	40.5	34.4	2.2	10.8	6.0	3.0	0.2	3.5	34.4	31.4	2.0	7.4
Berzék	933	187	14.9	12.8	0.8	3.9	2.1	1.1	0.1	1.2	12.8	11.7	0.7	2.7
	16373	**3518**	**259.7**	**222.3**	**14.1**	**67.9**	**37.4**	**18.7**	**1.5**	**21.5**	**222.3**	**203.6**	**12.7**	**46.4**
SUM1	**51792**	**10342**	**781.9**	**659.6**	**44.1**	**212.9**	**118.2**	**59.1**	**4.7**	**68.1**	**663.7**	**600.6**	**39.4**	**144.9**
SUM2	**50720**	**10128**	**764.8**	**644.9**	**43.1**	**208.4**	**115.7**	**57.9**	**4.6**	**66.6**	**649.1**	**587.1**	**38.5**	**141.8**

[1)] Not included in alternative 2

When the reductions for alternative 1 is calculated for the three recipient areas the result is as shown in Table 37.

Table 37. Reductions in loads for the municipal sector, alternative 1, for the different recipient areas.

Municipalities Recipient areas	P.e. corr.	Qtotal m^3/d	Reduction, tonnes/year BOD	SS	Tot-P	Tot-N
Hidasnémeti	1690	341	18,7	16,2	1,1	3,9
Tornyosnémeti	647	129	8,8	8,2	0,5	1,8
Göncruszka	714	143	9,8	9,0	0,6	2,0
Gönc	2538	501	35,8	31,2	2,0	7,3
Hernádvécse	851	170	11,6	10,7	0,7	2,4
Garadna	425	85	5,8	5,3	0,4	1,2
Novajidrány	1399	280	19,1	17,6	1,1	4,0
Vizsoly	929	186	12,7	11,7	0,7	2,6
1. SUM.Border-Vizsoly			*122,4*	*109,7*	*7,0*	*25,4*
Encs	7544	1272	74,9	64,8	5,5	20,5
Szalaszend	1129	226	15,5	14,2	0,9	3,2
Felsôdobsza	914	183	12,5	11,5	0,7	2,6
Forró	2239	448	30,6	28,1	1,7	6,4
Ináncs	1167	233	16,0	14,6	0,9	3,3
Szikszó	7048	1396	84,9	76,5	5,3	19,4
Homrogd	987	197	13,5	12,4	0,8	2,8
Alsóvadász	1477	295	20,2	18,5	1,1	4,2
Aszaló	1960	392	26,8	24,6	1,5	5,6
Halmaj	1761	347	24,1	22,1	1,4	5,0
Sajóhídvég	987	197	13,5	12,4	0,8	2,8
2. SUM Vizsoly-Gesztely			*332,5*	*299,6*	*20,5*	*75,9*
Gesztely	2753	551	37,7	34,5	2,1	7,8
Onga	4419	884	60,5	55,4	3,4	12,6
Hernádkak	1036	207	14,2	13,0	0,8	2,9
Hernádnémeti	3598	720	49,2	45,1	2,8	10,2
Böcs	2647	772	34,4	31,4	2,0	7,4
Berzék	933	187	12,8	11,7	0,7	2,7
3. SUM Gesztely-mouth			*208,8*	*191,3*	*11,9*	*43,6*
SUM 1	**51792**	**10342**	**663,7**	**600,6**	**39,4**	**144,9**

Sludge handling

Many of the pollutants that are removed during waste water treatment, can be found in the sludge. There are no heavy metal industry in the area which reduce the quality of the sludge.

In Table 38 typical ranges for metals in European waste water sludges without heavy industrial load are given for mechanical and biological treatment with nitrogen removal (Henze and Ødegaard, 1994).

Table 38. Typical metal content in sludge without heavy industrial load (mg/kg Dry Weight), Source: Henze and Ødegaard, 1994).

Component	Mechanical	Biological/Chemical with nitrogen removal
Cadmium(mg/kg SS)	5-10	6-12
Copper(mg/kg SS)	100-200	200-400
Chromium(mg/kg SS)	50-100	100-200
Lead(mg/kg SS)	200-300	200-400
Mercury(mg/kg SS)	4-10	4-10
Nickel(mg/kg SS)	30-80	3-80
Zinc(mg/kg SS)	1500-3000	2000-4000
Nitrogen(g N/kg SS)	20-40	15-40
Phosphorus(g N/Kg SS)	5-10	20-50
Potassium(g N/Kg SS)	2-4	40-60

Municipal waste water sludge is a good soil conditioner, because of its humus and nutrient content. The content of undesirable components may reduce the suitability, but it is expected to be low in Hernád. The knowledge about the content and consequences of organic micropollutants (CHC, PCB, PAH) is much less, but at this stage, however, such substances do not seem to constitute any severe threat as long as the industrial effluents to municipal sewer that contain such components are controlled (Henze and Ødegaard, 1994). Sludge used on farmland should in any case be monitored and controlled before it is used.

The number of cattle in the catchment of Hernád has decreased and there is need for sludge to use on farmlands. The sludge from the waste water treatment plants and the septic tanks should be treated and used as soil improvement. Dependent on which kind of agriculture use is being considered, the sludge should be hygienised in order to prevent microbiological pollution.

On the basis of the foregoing it is proposed to use sludge treatment consisting of thickening, anaerobic stabilisation, dewatering giving a dry matter content of more than 20%.

The sludge handling is strongly influenced by the size, and sludge handling at each of the small treatment plants will be very expensive. It is recommended to establish a common sludge treatment plant for both alternatives.

Efficient routines for emptying of septic tanks for the remaining part of the population in the catchment should also be established. The waste form these septic tanks can be transported and treated at the sludge plant.

7.2.3. Investments, operation and maintenance costs

Criteria used in the calculations

Sewers

The sewer system consists of both private sewers and main sewers collecting sewage from the single units. It is assumed that each house or unit has a 15 meter long private sewage system, and that the main sewers can be build by gravity. It is also assumed that the sewage system is build like separate systems giving 200 l/pd as a dimension criterion for the sewers.

Tables A6 and A7 in appendix gives the total length of the private sewers, the length of a sewer within each municipalities, and the length of the sewer between each municipality or/and from the waste water treatment plant to the recipient.

The unit cost for sewers are shown in Table 39.

Table 39. Unit costs used for sewer investment (NOK/meter)

	Private sewer	Main sewer			
litre/sec		<10	10-20	20-30	30-40
NOK/meter	500	500	600	650	700

The annual capital costs are based on an interest of 4% and 50 years lifetime.

The operation and maintenance costs are calculated on the basis of 3% extra costs on top of the annual capital costs.

Waste water treatment plants

The costs for the municipal waste water treatment plants are, as explained earlier, based on the KMT moving bed biological process with nitrogen removal and phosphorus removal by chemical precipitation.

The investment costs operation and maintenance costs for the waste water treatment plants are given in Table 40-41. The chemical costs are based on a process with pre-denitrification and post precipitation. The annual capitalised investment costs are based on a 4% interest rate and 20 years lifetime.

Table 40. O&M costs at municipal WWTP (1000 NOK/year)

P.e.	Energy kwh/day	Energy 1000 NOK/year	Chemical 1000 NOK/year	Total O&M 1000 NOK/year
1000	244	18	18	36
1500	342	25	27	52
2000	440	32	36	68
2500	539	39	45	84
3000	637	47	54	101
3750	816	60	68	127
5000	1114	81	90	171
10000	2228	163	150	313
15000	3342	244	225	469
20000	4456	325	300	625

Chemical costs more than 10 000 p.e. and postprecipitation=15 NOK/p.e. and year
Chemical costs less than10 000 p.e. and postprecipitation=18 NOK/p.e. and year

Table 41. Annual costs for waste water treatment plants

Pe	Investment process	Investment building	Annual capital 1000 NOK/year	Annual O&M 1000 NOK/year	Total annual 1000 NOK/year
1000	2500	500	251	36	287
1500	3300	500	310	52	362
2000	3900	500	354	68	422
2500	4500	500	398	84	482
3750	5500	500	472	127	599
5000	6000	500	508	171	680
10000	12000	500	950	313	1263
15000	18000	500	1391	469	1860
20000	24000	500	1833	625	2458

The waste water treatment plant is automated and, in both alternatives, it is suggested to establish an operation unit. One person can administer 2-3 plants. The program for training of operative personnel and the installation of the plants will be in the order of 500 000 NOK for alternative 1. It is assumed that this cost for one single plant is 100 000 NOK.

Sludge handling

The unit costs used for sludge handling is shown in Table 42, and are based on anaerobic stabilisation and dewatering, 4% interest and 20 year lifetime.

Table 42. Costs for sludge handling (source: Henze and Ødegaard).

	Capital cost US$ kg/SS	O&M costs US$ kg/SS	Total costs US$ kg/SS
Anaerobic stabilisation and dewatering	0.09	0.108	0.198

Costs for municipal waste water

Table 43 shows the total annual costs for waste water treatment plants and sewer systems for the two different alternatives.

Table 43. Annual costs (investments and O&M, 1000 NOK/year)

Alternative	Waste water treatment		
	Sewer	WWTP	Total Annual
1	10733	7020	17753
2	8498	9979	18477

Costs for sludge handling

The costs for sludge handling will be approximately 10 mill based on the unit costs. The unit costs are however given for a 100 pe plant. The unit costs in Hernád may therefore be a slightly higher (about 65 000 p.e.) and the total sludge investment costs in the range of 10-15 mill, giving annual costs including O&M in the range of 1.6-2.4 mill NOK/year.

Total costs

The yearly total costs including the sludge handling is about 20 million NOK/year, or 3.1 mill US$.

7.3. Review of measures in the agricultural sector

When today's run-off from agricultural activities was calculated in chapter 5, the factors (both natural and antropogenic) which cause run-off were discussed. This gives a good starting point for assessing possible pollution abatement measures in the region.

The measures that should be considered are both related to point sources (animal husbandries) and non- point sources (run-off from crop areas).

7.3.1. Measures for the animal husbandries

Prior to 1990, when large state owned animal husbandry farms dominated, the manure was kept in large tanks with only minor leakages. The problems for many East European regions was enormous volumes of manure that had to be transported over vast distances for spreading on crop land. The chemical fertiliser was easily accessible and inexpensive. Because of this the manure was not fully utilised.

Today the situation is quite different. High market prise on fertiliser has reduced the use of fertiliser by almost 75% from 1980 and the large state owned husbandries are split into smaller entities.

The manure which previously partly was regarded as a waste product is now more valued, but is still not utilised in a good manner. The problem for the small animal husbandries is that they seldom have an appropriate storage system. Much of the manure is stored outdoor in earth tanks with large leakages, or is directly spread onto the grass areas all year around, causing large losses of ammonia to air and nitrate to water. Phosphorous in the manure is also lost to a great extent when applied in the autumn and winter.

The key measures for the animal husbandries must therefore be:

- reduced use of earth tanks for storage of manure
- improved technical standard of the tanks, preventing leaks
- increase manure storage tanks, up to 6 months storage capacity
- application of manure only in the growing season
- application of manure to a larger area (better utilisation)

7.3.2. Measures for farms with plant production

The run-off from crop areas gives a large contribution to the pollution budget for both nutrients and suspended matters. A main problem with grain production is that the soil is left bare, without any plant cover, and without a well developed root system to stabilise the soil during the winter time. The soil temperature in winter is still sufficiently high for mineralisation of nitrogen. The risk of leakage of nitrogen to the ground and surface water are therefore high. The land is also susceptible of erosion of particle-bound phosphorus in this part of the year. Growing of vegetables, potatoes etc. will normally leave much plant residuals on the ground, which will be mineralised and with subsequent nutrient leakage to the ground and surface water.

More than half of the crop area is winter wheat, which is sown and germinates in the autumn. Some of the nitrogen in the ground is then utilised before the winter. Previously it was believed that the newly germinated wheat would bind the soil sufficient to prevent erosion. However the last years research (Eggestad 1992) shows that the erosion risk for these areas are nearly as high as for the areas that are plowed in the autumn and left without any plant cover at all during the winter.

The following measures should therefor be considered:

- adjust the use of fertiliser to plant requirements
- a possible change from winter to spring wheat without any tillage in the autumn
- no tillage in the autumn for the barley, maize and sunflower areas, especially on erodable (hilly) land
- split application of nitrogen fertiliser

- removal of plant residuals from potato and vegetable areas

The first measure includes the use of farm plans and soil sampling of the nutrient content of the soil. It has not been possible to calculate costs and effects for the first and last measure. The remaining are described in the following section.

As a supplementary measure, vegetation strips between cultivated land and the surface waters could be effective, both within the catchment of tributary creeks and the Hernád itself, in order to increase the retention of nutrients coming from the arable land.

Areas which are likely to be eroded should be converted to meadows or pastures in order to avoid plowing.

7.3.3. Effects of agricultural measures

7.3.3.1. Effects achieved by improving the technical standards of manure tanks.

When assessing the effects of the improvement of technical standard on manure tanks, it is presupposed establishment of tanks without leakages and without drainage. This implicates no loss of phosphorous, but still some loss of nitrogen through volatilisation. This loss will however be the same as before, when stored in earth tanks, and not a substantial loss. The effects in reduced P- an N leaks to surface and sub-surface water are shown in Table 44.

Table 44. Effects (reduction) of phosphorus and nitrogen input to surface water when installing sealed manure tanks.

Effects (reductions)	Recipient Area	Tot-P kg/y	Tot-P kg/y sum recip. area	Tot-N kg/y	Tot-N kg/y sum recip. area
Telkibánya	Upstream Hidasnémeti	63		492	
Novajidrány	Hidasnémeti -Vizsoly	126		984	
Unspecified	Hidasnémeti -Vizsoly	683	*872*	3940	*5416*
Halmaj	Vizsoly-Gesztely	1010		7180	
Encs	Vizsoly-Gesztely	189		1476	
Fulókércs	Vizsoly-Gesztely	95		780	
Gesztely	Vizsoly-Gesztely	315		2460	
Unspecified	Vizsoly-Gesztely	2009	*3618*	11585	*23481*
Hernádnémeti	Gesztely-Böcs	189		1476	
Hernádkak	Gesztely-Böcs	31,5		246	
Böcs	Gesztely-Böcs	189		1476	
Sajóhidvég	Downstream Böcs	126		984	
Unspecified	Gesztely-Böcs	376	*911*	2166	*6348*
SUM		**5401**		**35244**	

7.3.3.2. Effects of changing from autumn to spring tillage.

A change from autumn to spring tillage for all crops without potato and vegetables on easy erodable land could reduce the run-off of nutrients substantially. About 60% of the area can be considered to be easily erodable, but the variation is large in the different recipient areas (Table 45). The change from autumn to spring plowing for e.g. areas growing barley, may on easily erodable areas have an effect up to 56% for phosphorus and 30 % for nitrogen (Eggestad 1992, 1993). Taking into account that some of these areas only are disked once a year, and that they have a rather low precipitation rate during the autumn, winter and spring, the effect of this measure have been stipulated to 40% for phosphorus and 23% for nitrogen. The change from winter wheat to spring wheat without plowing in the autumn has somewhat lower reduction potential, 28% for phosphorus and 8 % for nitrogen. Assuming that half of the easily erodable land consists of winter wheat, and the other half of plants with a shorter growth period, barley, maize, the mean reduction on the easily erodable areas was calculated to 34% for phosphorus and 15% for nitrogen. These measures will influence the crop practice on approximately 23 000 of the total 41 000 ha of tilled crops in the Hernád watershed.

Table 45. Effects of changing from autumn to spring tillage on easily erodable land.

Recipient area	Crop area	Easily erodable %	kg P/y	kg N/y
1. Border - Vizsoly	3563	40	485	14966
2. Vizsoly - Gesztely	18336	70	2494	77012
3. Gesztely - mouth	979	20	133	4113
SUM	**22878**		**3112**	**96091**

7.3.3.3. Effects of adjusting the application time of manure.

For this measure the reductions in run-off and volatilisation can be substantial through application of manure only in the growing season.

The statistics on manure use, show that only 45 ha of the grassland area in the whole Borsod-Abaúj-Zemplén County receives manure. More than 98% of the manure is spread on the tillage areas. Since the storage capacity is very limited, it is assumed that 50% of the manure is spread outside the plants growing period. About 80% of the nitrogen spread outside the growing season will ether volatilise to air or run-off to surface or sub-surface water. Much more of the phosphorus will remain in the soil, the rate depends on susceptibility of erosion. It is assumed that only 20% of the phosphorus is lost. The total effects of this measure is shown in Table 46.

Table 46. Effects (reductions) of spreading of manure only in the growing season.

	Recipient Area	Tot-P kg/y	Tot-P kg/y, sum recip. area	Tot-N kg/y	Tot-N kg/y sum recip. area
Telkibánya	Upstream Hidasnémeti	126		3280	
Novajidrány	Hidasnémeti -Vizsoly	252		6560	
Unspecified	Hidasnémeti -Vizsoly	1366	1744	26265	36105
Halmaj	Vizsoly-Gesztely	2020		47867	
Encs	Vizsoly-Gesztely	378		9840	
Fulókércs	Vizsoly-Gesztely	190		5200	
Gesztely	Vizsoly-Gesztely	630		16400	
Unspecified	Vizsoly-Gesztely	4018	7236	77231	156537
Hernádnémeti	Gesztely -Böcs	378		9840	
Hernádkak	Gesztely -Böcs	63		1640	
Böcs	Gesztely -Böcs	378		9840	
Sajóhidvég	Downstream Böcs	252		6560	
Unspecified	Gesztely -Böcs	751	1822	14437	42317
SUM		10802		234960	

7.3.3.4. Effects of split application of nitrogen fertiliser.

Split application of nitrogen fertiliser means that the nitrogen fertiliser is spread twice a year. The fertilisation in the spring is reduced. In wet years with a high grade of vegetative growth, the second spreading of fertilisation later in the growing season contains about the same amount of fertiliser which is reduced in the spring. This gives larger crops with a higher protein content. Years with a dry spring and early summer, there is no need for applying nitrogen fertiliser the second time. In Norway, one out of five years is so dry that the second spreading will not be done.

The mean effect of this measure is assumed to be 5,3 kg/ha for nitrogen (Vagstad 1995). It is especially effective for different types of grains. Table 47 shows the nitrogen effect for areas of wheat and barley.

Table 47. Effects of split application of chemical fertiliser to grain areas.

Recipient area	Tilled area, ha	koeff. kg N/ha	kg N kg/y
1. Border - Vizsoly	5791	5,3	30690
2. Vizsoly - Gesztely	17027	5,3	90241
3. Gesztely - mouth	3183	5,3	16869
SUM	**26000**		**137800**

7.3.3.5. Sum of effects for measures in the agricultural sector.

The measures where it has been possible to calculate the effects for are described in the section above. For the tree recipient areas, Table 48 gives an overview of the sum of all the measures in the agricultural sector.

Table 48. Overall effects (reductions) of measures within the agricultural sector.

Overall reductions from agricultural measures	Sealed manure tanks		Spring tillage		Split application	Application time of manure		TOTAL FOR P	TOTAL FOR N
	Tot P kg/y	Tot N kg/y	Tot P kg/y	Tot N kg/y	Tot N kg/y	Tot P kg/y	Tot N kg/y	kg/y	kg/y
1. Border-Vizsoly	872	5416	485	14966	30690	1744	36105	3101	87178
2. Vizsoly-Gesztely	3618	23481	2494	77012	90241	7236	156537	13347	347271
3. Gesztely-mouth	911	6348	133	4113	16869	1822	42317	2866	69647
SUM	5401	35244	3112	96092	137800	10802	234960	19315	504096

7.3.4. Investments, operation and maintenance costs

7.3.4.1. Effects on improving the technical standards of manure tanks.

There are different types of manure tanks that could be built. Focus is put on two alternatives, namely

- building of concrete tanks on site
- pre-fabricated tanks

The pre-fabricated tanks can be delivered from different producers. One possible concept is a self-assembled tank with walls of steel plates and a strong PVC- foil sealing the tank inside. The tank is circular and needs no fundamentation. The tanks are produced in Norway and, because of the limited weight, the costs for transportation to Hungary are small.

The tank is open, but can be delivered with roof for a higher price (about 50% more). The possible volumes are 21-530 m^3. The price for the two most common types (85 and 300 m^3) is 20 000 and 45 500 NOK. The tanks are self assembled in 30-60 man hours. With salaries for Hungarian farmers set to 400 000 forints per year (220 forints/hour) and 50 hours work, the cost is 11 000 forints or 610 NOK per tank.

Another alternative is to build earth tanks with the same PVC- foil sealing. This alternative is less expensive for tank volumes of more than 2-300 m^3, but more expensive for smaller ones. This is due to more use of PVC-foil because of the slope side of an earth tank, and building of non-climbable fence.

The costs for this tank type are about 20-30% less than pre-fabricated concrete tanks.

The building of a concrete tank on site could be cost-effective, regarding the low salaries in Hungary. However it is difficult to build tanks that will not start to leak after some time. This is one of the reasons for why such tanks seldom are built in Scandinavia. The costs for this alternative is therefore not elaborated.

Based on statistics of animal types and numbers, production-coefficients of P and N (kg P and N/ind*day), and total productions of organic manure (litre/ind*day), the mean content of P and N in manure is calculated to 0,09 % P and 0,50 % for N. For P, this is in the same order of magnitude as what measured in manure from Norwegian milking cows. For N it is somewhat higher.

The total content of nutrients in a 300 m^3 tank (mean 150m^3) will be 135 kg P and 750 kg N. The estimated reductions in inputs are 13,5 kg for P and 90 kg for N (with an assumed 10 and 12% leakage from prior earth tanks). The total animal stock in Hernád watershed produces about 118 000 m^3 manure per year. There will be a need for 295 tanks of this type (300 m^3). It is here calculated with 6 months storage capacity and 50% dilution with water of the manure to make it able to be pumped. The investment costs of 295 tanks will be 13 423 thousand NOK (TNOK). The assembly cost will be 180 TNOK. With an economic life span of 20 years these costs will give an annual cost of 1 001 TNOK.

7.3.4.2. Costs of changing from autumn to spring tillage

Depending on soil type there is reported both reduced and enhanced crop yield on areas that have shifted from autumn to spring tillage. Especially on soil with high silt content, there is reported enhanced crop yield on areas which are tilled in the spring (Hansen & Romstad 1991).

Winter grain will sometimes give a higher yield than spring grain, especially on soils that are susceptible to drought. Winter grain will therefore reduce the risk for lower yield in years with drought in the early summer. On the other hand, with winter grain, there is danger of lower yield when the winter is harsh. This is a special problem on soil with much silt content and fluctuations between frost and warmth.

As a mean average for Norwegian crops there is calculated with a reduction in yield of 5% when shifting from winter grain(wheat) to spring grain. With world market prices on grain (1.1 NOK/kg)this means a rise in costs of about 18 NOK/daa[1]. The same average reduction in yield for these parts of Hungary is proposed. Up to 23 000 ha or 230 000 daa could be influenced by this, which means a total annual cost of 4 140 TNOK.

7.3.4.3. Costs for adjusting the application time of manure

The predominant cost for this measure is the building of manure tanks, which already has been calculated. There will however be a loss of yield because of postponed time for sowing. This is calculated to 10 kg/daa for 4 days later sowing. Reduced yield because the earth is packed to much together, of about 5% should also be calculated in. The total cost for yield loss is calculated to 29 NOK/ daa (Sandberg 1991). For 22 000 daa this means a cost of 638 TNOK/year.

When the manure is spread during the plants growing season, it gets a higher value. This gives a reduction in costs when the measure is implemented.

7.3.4.4. Costs of split application of nitrogen fertiliser.

This measure is relevant for wheat and barley, which are grown on about 26 000 ha. The investment of a centrifugal spreader is a prerequisite. This machine is only used for the second

[1] daa = 1000 m^3 or 0,1 ha

spreading, and in only 4 of 5 years. The yearly costs of this machine are, if leased or bought together with other farmers, about NOK 6/daa (Sandberg 1991). The yearly extra working effort is by NILF (1992) set to 0.1 hour/daa, adjusted for the use only once every five years. This cost will be 22 forints/daa or 1.2 NOK/daa

A reduction in yield from the driving tracks (from the tractor) is set to 7,5 kg/daa, but the gain in crop in years with second fertilisation is 10 kg/daa, provided that the same sum of N fertilisation is applied. The net gain of 2,5 kg/daa is priced to 2.75 NOK/daa. With a subtraction of the extra working effort mentioned above, there is still a net gain of 2.55 NOK/daa, or 663 TNOK/year.

7.3 Optimal pollution abatement programme

7.3.1 Cost/benefit

Different sets of cost-effective abatement measures for each of the five alternative objectives proposed in chapter 6.1.2 should in principal be designed. The situation is however that a majority of all pollution in Hernád is coming from the Slovakian republic. Since alternative measures from these activities are not included in the analysis, there will be difficult to reach ambitious environmental goals only by implementing measures on the Hungarian side. It will obviously not be cost-effective to implement many marginal measures in Hungary, and none in Slovakia.

Since there hardly is any industry on the Hungarian side of the border, no measures to reduce the problem of too high metal contents are proposed. The problems that partly could be solved by implementing measures at the Hungarian side are connected to reduction of organic matter, particles and nutrients.

Table 49 gives an overview of the total effect and costs for the reviewed measures.

Table 49. Effects and costs of the set of measures proposed by sector and type of measure. Annual costs in thousand NOK and effects in kg/year. Thousand forints in brackets.

Sector, type of measure	Annual costs#	Red. P kg/y	Red. N kg/y	Cost-eff. P	Cost-eff. N
Municipal:					
Alt. 1, Intermunicipal WWTP	20 000(360 000)	39 400	144 900	0,51	0,138
Agriculture:					
Sealed manure tanks	1 001(18 018)	5 401	35 244	0,19	0,028
Spring tillage	4 140(74 520)	3 112	96 092	1,33	0,043
Application time of manure	638(11484)	10 802	234 960	0,06	0,003
Split application	-663(-11934)	0	137 800		-0,005
SUM/ ***MEAN***	**25 116(452 088)**	**58 715**	**648 996**	***0,52***	***0,041***

Total annual cost including discounted investment costs and annual operation and maintenance cost.

For Objective 1, to satisfy today's user interests, it is necessary to reduce NH_4, NO_2, Mg, and Ni (Table 31). As mentioned, Ni and other metals must be dealt with on the Slovakian side. By reducing the loads of nitrogen from agriculture and municipal waste water the total abatement will reach approx. 650 tonnes/y, calculated as total N. The requirement is to reduce about 800 tonnes/y of NH_4-N at Gesztely and ca 1200 tonnes/y at Hidasnémeti. This means that even with all the reviewed measures, the requirements for abatement of nitrogen is not met in any portion of the river. However, reduction of total-N of 65 tonnes/y together with substantial reduction of organic matter would undoubtedly improve the water quality.

For objective 2, providing drinking water quality up to Vizsoly, the requirements for nitrogen are the same as for objective 1, but in this case there is also a required reduction of phosphorus of 367 tonnes/y at Gesztely. This is not achievable with the reviewed measures. Only some 60 tonnes/y could be reduced by implementing measures on the Hungarian side.

For phosphorus, the measures in the municipal sector has a cost-effectiveness about mean value, compared with the agricultural measures. The agricultural measure, which implies a shift from autumn to spring tillage, is a marginal measure in this analysis, regarding phosphorus. This is not only restricted to barley and other cereals that already are sown in the spring, but also includes a shift from growing winter wheat to spring wheat. Leaving the cereals root system intact during the winter will stabilise the soil and therefore not leave the soil susceptible to erosion and run-off of phosphorus and to a certain extent of nitrogen. The winter wheat, which by far is the mostly grown cereal in the area, has however a certain (but small) capacity to bind the soil, and the mean effect of this measure is therefore reduced. In combination with a reduction in yield of about 5%, the cost-effectiveness is therefore moderate. This measure should be implemented on the cereal areas witch are susceptible to erosion, about 50% of the total grain area.

The cost-effectiveness of nitrogen is much better for the agricultural measures than for the municipal ones. The measure "split fertilisation" has in fact a negative cost-efficiency, this means that the farmer actually saves money on implementing this measure. The other measures within the agricultural sector are 3-50 times cheaper than the measures in the municipal sector, regarding nitrogen.

To meet the requirements for objectives 2-5 this can only be done by incorporating measures on the Slovakian side. This is the case for nutrients as well as for suspended matter and heavy metals. Especially for the latter category, the reduction potential in Hungary is very small.

An analysis like this would normally include a larger set of reviewed measures. There would be different alternative plans for each of the objectives, and for each of the recipient areas. Because of the limited efforts which can put in on the Hungarian side, which only covers 20% of the total catchment area, this analysis has not been as broad as usual. This only underlines that this kind of cost-effective and catchment oriented approach, will only be fully successful when all polluters at all sectors and the total geographic area, is included. The analytical method and strategy will, however, be the same if the Slovakian part of the catchment area is included. We hope that such an analysis will be conducted in the near future.

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Appendix

Table A1. Hungarian and Norwegian Water Quality Criterias.

Criterias	C	Profile	River km		Group A : Oksygen Parameter					Group B : N - P Eutropication							Group D : Inorganic Micropollutants							
				Q	O2 m.	BOD 5	COD.Mn	COD.Cr	Sap.Ind.	N-NH4	N-NO2	N-NO3	Tot-N	P-PO4	Tot-P.	Klor-a	Hg	Cd	Ni	Zn	Pb	Cr	Cu	As
				m3/s	%	mg/l	mg/l	mg/l		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
Hungarian	C90	Hernadszurdok	95,1	45,2	138	8,80	7,2	24,6	(-)	3,8	0,36	4,2	9,57	0,52	0,57	21,32	0,23	3,00	25,19	116,0	23,20	14,97	16,73	8,90
Criterias	C90	Hidasnemeti	97,6	47,6	138	8,80	7,7	28,0	2,77	3,9	0,36	4,1	9,37	0,49	0,57	17,12	0,28	3,00	25,88	140,0	25,80	20,10	19,88	7,80
	C90	Gesztely	24,4	54,0	118	7,77	6,4	22,0	(-)	2,4	0,14	4,5	9,10	0,42	1,70	69,60	0,21	2,29	28,19	114,4	25,00	11,76	14,34	8,60
	C90	Belus-patak	0,9	483,2			97,3	270,8		57,9		58,9												
	C90	Gonci-patak	7,0	76,5			49,0	115,5		30,6		1,2												
	C90	Vadasz-patak	6,5	353,1			82,1	191,8		100,3		54,0												
	C90	Hernad Uzenviz Csat	9,7	170,0			24,5	47,7		8,7		12,2												
	C90	Barsonyos Csatorna	17,2	78,4			15,7	41,3		1,0		10,9												
	C90	Barsonyos Csatorna	17,3	144,3			(-)	183,9		89,1		11,5						90,00	87,00	77420	4,00		51,00	
Norwegian	Cav	Hernadszurdok	95,1	25,5	124	6,93	5,6	19,4	(-)	1,6	0,18	3,5	6,90	0,31	0,43	10,38	0,16	1,26	12,75	85,0	11,83	6,68	9,25	6,25
Criterias	Cav	Hidasnemeti	97,6	26,2	127	6,95	5,9	20,7	2,41	1,7	0,18	3,3	7,23	0,33	0,48	9,48	0,18	1,31	12,84	91,6	13,52	8,47	10,58	5,57
	Cav	Gesztely	24,4	27,2	105	5,95	5,0	16,8	(-)	0,8	0,08	3,7	6,50	0,25	0,64	27,24	0,15	1,15	12,35	76,0	16,35	5,77	8,30	5,71
	Cav	Belus-patak	0,9	435,4			64,8	164,6		33,7		26,4												
	Cav	Gonci-patak	7,0	63,1			38,0	91,0		22,0		0,8												
	Cav	Vadasz-patak	6,5	319,9			44,4	107,0		45,2		29,7												
	Cav	Hernad Uzenviz Csat	9,7	154,5			15,4	30,0		3,1		7,3												
	Cav	Barsonyos Csatorna	17,2	52,6			11,5	30,5		0,5		6,8												
	Cav	Barsonyos Csatorna	17,3	91,5			(-)	87,7		26,6		5,1						90,00	75,00	24744	4,00		32,50	
Hungarian	C90	Hernadszurdok			III	III	II			V	V	II		V	V	III	III	IV	II	III	III		III	I
Criterias	C90	Hidasnemeti			III	III	II			V	V	II		V	V	II	III	IV	II	III	III		III	I
	C90	Gesztely			II	III	II			V	IV	II		V	V	III	III	IV	II	III	III		III	I
	C90	Belus-patak					V	V		V		V												
	C90	Gonci-patak					V	V		V		II												
	C90	Vadasz-patak					V	V		V		V												
	C90	Hernad Uzenviz Csatorna					V	IV		V		IV												
	C90	Barsonyos Csatorna					IV	IV		IV		IV												
	C90	Barsonyos Csatorna					(-)	V		V		IV						V	V	V	I		III	
Norwegian	Cav	Hernadszurdok					III						V		V	IV	IV	V	III	IV	V	III	III	
Criterias	Cav	Hidasnemeti					III						V		V	IV	IV	V	III	IV	V	III	III	
	Cav	Gesztely					III						V		V	V	IV	V	III	IV	V	III	III	
	Cav	Belus-patak					V																	
	Cav	Gonci-patak					V																	
	Cav	Vadasz-patak					V																	
	Cav	Hernad Uzenviz Csatorna					V																	
	Cav	Barsonyos Csatorna					IV																	
	Cav	Barsonyos Csatorna					(-)											V	V	V	III		V	

Cont. Table A1. Hungarian and Norwegian Water Quality Criterias.																					
Criterias	C	Profile	River km		Group D2:Org. Mi		Group E : Div. parameter														
				Q	Fenols	Anion.De	Temp.	pH	Kond.	Alkal.M.	Kalcium	Magnes.	Na	K	Chloride	Sulfate	Mn	TS	SS	Fe	Min. Oil
				m3/s	mg/l	mg/l	gr.C		uS/cm	mval/l	equiv/l	equiv/l	mg/l	mg/l	equiv/l	equiv/l	mg/l	mg/l	mg/l	mg/l	mg/l
Hungarian	C90	Hernadszurdok	95,1	45,2	0,0043	0,053	19,72	7,89	677	4,12	(-)	2,16	38,8	76,00	1,65	2,21	0,32	479	131	1,81	0,19
Criterias	C90	Hidasnemeti	97,6	47,6	0,0036	0,053	19,72	7,86	670	4,24	3,92	(-)	37,7	7,20	1,53	2,06	0,31	457	139	2,28	0,19
	C90	Gesztely	24,4	54,0	(-)	0,060	21,58	8,19	699	4,08	(-)	(-)	42,0	8,20	1,70	2,29	0,30	486	99	1,99	0,18
	C90	Belus-patak	0,9	483,2		2,393		7,70					182,0					1106	116		
	C90	Gonci-patak	7,0	76,5		3,338		7,66					217,5					1164	62		
	C90	Vadasz-patak	6,5	353,1		1,840		7,90					258,5					1533	124		
	C90	Hernad Uzenviz Csat	9,7	170,0		0,324		7,96					104,4					889	33		
	C90	Barsonyos Csatorna	17,2	78,4		0,272		8,22					117,5					918	30		
	C90	Barsonyos Csatorna	17,3	144,3		(-)		8,43					469,9					2665	127	6,64	
Norwegian	Cav	Hernadszurdok	95,1	25,5	0,0028	0,033	10,89	7,67	564	3,49	(-)	1,74	27,0	61,42	1,16	1,81	0,19	404	83	1,12	0,13
Criterias	Cav	Hidasnemeti	97,6	26,2	0,0029	0,032	10,87	7,66	554	3,58	3,44	(-)	26,0	5,80	1,07	1,73	0,20	392	86	1,31	0,12
	Cav	Gesztely	24,4	27,2	(-)	0,038	11,79	7,92	575	3,53	(-)	(-)	28,1	6,65	1,20	1,87	0,17	416	49	0,73	0,12
	Cav	Belus-patak	0,9	435,4		1,292		7,47					146,6					911	71		
	Cav	Gonci-patak	7,0	63,1		3,250		7,53					135,4					888	36		
	Cav	Vadasz-patak	6,5	319,9		0,749		7,63					207,9					1342	79		
	Cav	Hernad Uzenviz Csat	9,7	154,5		0,231		7,48					71,5					645	20		
	Cav	Barsonyos Csatorna	17,2	52,6		0,152		7,82					84,6					782	26		
	Cav	Barsonyos Csatorna	17,3	91,5		(-)		7,61					255,1					1596	59	3,26	
Hungarian	C90	Hernadszurdok			I	I		I	II								IV			V	
Criterias	C90	Hidasnemeti			I	I		I	II								IV			V	
	C90	Gesztely			I	I		I	II								IV			V	
	C90	Belus-patak				V		I													
	C90	Gonci-patak				V		I													
	C90	Vadasz-patak				V		I													
	C90	Hernad Uzenviz Csatorna				III		I													
	C90	Barsonyos Csatorna				II		I													
	C90	Barsonyos Csatorna				(-)		I												V	
Norwegian	Cav	Hernadszurdok						I									V		V	V	
Criterias	Cav	Hidasnemeti						I									V		V	V	
	Cav	Gesztely						I									V		V	V	
	Cav	Belus-patak						I											V		
	Cav	Gonci-patak						I											V		
	Cav	Vadasz-patak						I											V		
	Cav	Hernad Uzenviz Csatorna						I											V		
	Cav	Barsonyos Csatorna						I											V		
	Cav	Barsonyos Csatorna						I											V	V	

Table A2. Hungarian classification for water use. Hungarian 1 and 2 are imperative and guideline vaues.
"Class" is the corresponding water quality class in the Hungarian system.

Parameter	Unit	Drinking Water				Irrigation				Animal husbandy				Biodiv.				Fishery				Recreation and Swimming				Industry			
		Hungarian 1		Hungarian 2		Hungarian 1		Hungarian 2		Hungarian 1		Hungarian 2		Hungarian 1		Hungarian 2		Hungarian 1		Hungarian 2		Hungarian 1		Hungarian 2		Hungarian 1		Hungarian 2	
		Limit	Class	Limit	Class	Limit	Class	Limit	Class	Limit	Class	Limit	Class	Limit	Class	Limit	Class	Limit	Class	Limit	Class	Limit	Class	Limit	Class	Limit	Class	Limit	Class
BOD	mg/l	3	I											5	II	10	III	6	II	12	IV								
COD - Mn	mg/l	10	III	20	IV									8	II	15	III	8	II	15	III	8	II	15	III				
Ammonium	mg/l	0,04	I							0,05	I	0,5	II	0,05	I	0,5	II	0,05	I	0,5	II								
Nitritt	mg/l									0,01	I	0,05	III	0,01	I	(-)		0,01	I	0,1	III								
Nitrate	mg/l	5,65	III	11,3	IV									5	II	10	III									40	V	40	V
Coliforme	100ml	50	I			500	II	10000	IV	500	III	10000	IV																
Fekal C	100ml	20	I			100	II	2000	III	100	II	2000	III																
Phosphorus	µg/l	1000	IV	3000	V									1000	IV	3000	V												
PO4	µg/l	176	III											300	IV	2000	V	300	IV	2000	V								
Anion. Det.	mg/l	0,2	II											0,2	II	0,5	IV	0,2	II	0,5	IV	0,3	III	1	V				
Chlorophyll	µg/l													20	II	80	IV												
Aluminium	µg/l					5	V	20	V					1000	V	5000	V												
As	µg/l	10	I	50	III	50	III	100	IV	50	III	200	V	50	III	100	IV	50	III	1000	IV	100	IV	500	V				
Hg	µg/l	0,5	III	1	IV	0,5	III	1	IV	0,5	III	1	IV	0,5	III	1	IV	0,5	III	1	IV	0,5	III	1	IV				
Cd	µg/l	1	II	5	IV	3	IV	20	V	3	IV	5	IV	3	IV	5	IV	3	IV	5	IV	3	IV	10	V				
Ni	µg/l					20	II	150	IV	100	IV	1000	V	25	II	150	IV	50	III	2000	IV	500	V	1500	V				
Zn	µg/l	500	V	3000	V	200	IV	1000	V	1000	V	5000	V	300	IV	1000	V	100	III	1000	V	500	V	5000	V				
Pb	µg/l			50	III	50	III	2000	V	50	III	100	IV	10	II	50	III	50	III	250	V	100	IV	500	V				
Cr	µg/l			50	IV	100	IV	2000	V	250	V	1000	V	150	V	250	V	100	IV	250	V	100	IV	500	V				
Cu	µg/l	20	III	50	III	200	V	1000	V	200	V	1000	V	200	V	1000	V	100	IV	1000	V	500	V	5000	V				
Fe	µg/l	100	I	300	III	1000	IV	3000	V					0,3	III	1	IV	0,5	III	2	V								
Mn	µg/l	50	I			200	III	500	IV					0,1	II	0,3	IV	0,5	IV	1	V								

Table A3. Sewage loads from rural areas.

Municipality	Popul.	Area km2	Rural Sewage % Rural	Rural Sewage Pop	Rural Sewage, after treatm., ton/year BOD	COD	SS	Tot-P	Tot-N	Recipientarea Vizoly	Geztely	Mouth	Soil km	Primary recipient Length(km)	Name Primary recipient	Recipient area Length(km)
Abaújszolnok	134	865	100,0	134	2,1	5,3	1,8	0,1	0,6		x			27	Servel,Vadasz-p-Vadasz patak	6
Abaújvár	309	732	100,0	309	4,9	12,3	4,2	0,3	1,3	Up. Hld.				0,5	Husdat-p	-10
Alsódobsza	377	1070	100,0	377	6,0	15,1	5,2	0,3	1,6		x		1			10
Alsógagy	142	628	100,0	142	2,3	5,7	1,9	0,1	0,6		x			22	Vasonca	17
Alsóvadász	**1477**	**2291**	100,0	1477	23,6	59,0	20,2	1,3	6,1		x			14	Vadasz-p	6
Aszaló	**1960**	**2536**	100,0	1960	31,3	78,2	26,8	1,7	8,2		x			3	art.ch	11
Baktakék	767	1881	100,0	767	12,2	30,6	10,5	0,7	3,2		x			19	Vasonca-p	17
Beret	226	678	100,0	226	3,6	9,0	3,1	0,2	0,9		x			16	Vasonca-p	17
Berzék	933	1060	100,0	933	14,9	37,2	12,8	0,8	3,9			X			Hernad	5
Böcs	**2643**	**2432**	92,8	2452,49	39,2	97,9	33,6	2,1	10,2			x		0	Hernad	10
Csenyéte	276	997	100,0	276	4,4	11,0	3,8	0,2	1,1		x		1	25	Vasonca-p	17
Csobád	721	1185	100,0	721	11,5	28,8	9,9	0,6	3,0		x			6	art.ch-Belus-P	19
Detek	313	968	100,0	313	5,0	12,5	4,3	0,3	1,3		x			15	Vasonca-p	17
Encs	**6663**	**3113**	59,0	3931,81	62,8	157,0	53,8	3,4	16,4		x			11	Belus-p	19
Fancsal	365	977	100,0	365	5,8	14,6	5,0	0,3	1,5		x			12	Galambos-p-Vadasz-patak	19
Felsôdobsza	914	1519	100,0	914	14,6	36,5	12,5	0,8	3,8		x			0	Hernad	21
Felsôgagy	170	1447	100,0	170	2,7	6,8	2,3	0,1	0,7		x			25	Vasonca	17
Felsôvadász	525	1864	100,0	525	8,4	21,0	7,2	0,5	2,2		x			27	Kupel Vadsz p-Vadasz patak	6
Forró	**2239**	**1901**	100,0	2239	35,8	89,4	30,6	1,9	9,3		x			10	Galambos-Belus-P	19
Fulókércs	327	1859	100,0	327	5,2	13,1	4,5	0,3	1,4		x			33	Belus-p	19
Gadna	253	809	100,0	253	4,0	10,1	3,5	0,2	1,1		x			31	Kupel Vadsz p-Vadasz patak	6
Gagyapáti	18	322	100,0	18	0,3	0,7	0,2	0,0	0,1		x		2	22	Vasonca	17
Garadna	425	974	100,0	425	6,8	17,0	5,8	0,4	1,8	x				3	Garadna-p	5
Gesztely	**2753**	**2882**	100,0	2753	44,0	109,9	37,7	2,4	11,5		x			0	Hernad	0
Gönc	**2378**	**3726**	95,0	2260,25	36,1	90,2	30,9	2,0	9,4	x				8	Gøncl-p	7
Göncruszka	714	1669	100,0	714	11,4	28,5	9,8	0,6	3,0	x				4	Gøncl-p	7
Halmaj	**1761**	**1259**	100,0	1761	28,1	70,3	24,1	1,5	7,3		x			3	Vasonca	17
Hangács	693	2255	100,0	693	11,1	27,7	9,5	0,6	2,9		x			20	Kerezl-p-Vadasz patak	6
Hegymeg	133	570	100,0	133	2,1	5,3	1,8	0,1	0,6		x			27	Vadasz patak	6
Hejce	298	951	100,0	298	4,8	11,9	4,1	0,3	1,2	x				6	Villmany	2
Hernádbűd	166	592	100,0	166	2,7	6,6	2,3	0,1	0,7		x				Hernad	25
Hernádkak	**1036**	**1090**	100,0	1036	16,5	41,4	14,2	0,9	4,3			x			Hernad	18
Hernádkércs	325	742	100,0	325	5,2	13,0	4,4	0,3	1,4		x				Hernad	19
Hernádnémet	**3598**	**2876**	100,0	3598	57,5	143,6	49,2	3,1	15,0			x			Hernad	14
Hernádpetri	235	1707	100,0	235	3,8	9,4	3,2	0,2	1,0	x				9	Garadna-p	5
rnádszentand	357	699	100,0	357	5,7	14,3	4,9	0,3	1,5		x		1			25
Hernádszurdok	253	436	100,0	253	4,0	10,1	3,5	0,2	1,1	x				0	Hernad	14
Hernádvécse	**851**	**1689**	100,0	851	13,6	34,0	11,6	0,7	3,5	x				5	Garadna-p	14
Hidasnémeti	**1167**	**1618**	97,3	1135,4	18,1	45,3	15,5	1,0	4,7	x				0	Hernad	0
Homrogd	**987**	**1343**	100,0	987	15,8	39,4	13,5	0,9	4,1		x			20	Vadaz-p	6
Ináncs	**1167**	**1095**	100,0	1167	18,6	46,6	16,0	1,0	4,9		x			5	Belus-p	19
Irota	157	1233	100,0	157	2,5	6,3	2,1	0,1	0,7		x			32	Vadasz-patak	6
Kéked	255	1301	100,0	255	4,1	10,2	3,5	0,2	1,1	Up. Hld.				1	Husdat-p	-15

Table A3. Sewage loads from rural areas.

Municipality	Popul.	Area	Rural Sewage		Rural Sewage, after treatm., ton/year					Recipientarea Vizoly	Geztely	Mouth	Soil	Primary recipient	Name	Recipient area
Kiskinizs	322	718	100,0	322	5,1	12,9	4,4	0,3	1,3		x			0	Hernad	18
Korlát	343	791	100,0	343	5,5	13,7	4,7	0,3	1,4	x			3			0
Kupa	199	784	100,0	199	3,2	7,9	2,7	0,2	0,8		x			24	Kupel Vadsz p-Vadasz patak	6
Lak	548	1976	100,0	548	8,8	21,9	7,5	0,5	2,3		x			27	Vadasz	6
Léh	478	843	100,0	478	7,6	19,1	6,5	0,4	2,0		x			6	Vasonca	14
Litka	72	670	100,0	72	1,1	2,9	1,0	0,1	0,3		x			47	Belus-p	19
Monaj	227	1153	100,0	227	3,6	9,1	3,1	0,2	0,9		x			19	Servel,Vadasz-p-Vadasz patak	6
Nagykinizs	373	657	100,0	373	6,0	14,9	5,1	0,3	1,6		x				Hernad	17
Novajidrány	**1399**	**1431**	100,0	1399	22,3	55,9	19,1	1,2	5,8	x				3	art.ch	2
Nyésta	78	689	100,0	78	1,2	3,1	1,1	0,1	0,3		x			27	Servel,Vadasz-p-Vadasz patak	6
Onga	**4419**	**3150**	100,0	4419	70,6	176,4	60,5	3,8	18,4			x		10	Barsanyanos	10
Pere	456	953	100,0	456	7,3	18,2	6,2	0,4	1,9		x				Hernad	25
Pusztaradvány	201	714	100,0	201	3,2	8,0	2,8	0,2	0,8	x				3	Gardna-P	5
ásonysápberen	436	908	100,0	436	7,0	17,4	6,0	0,4	1,8		x			8	Vasonca	17
Sajóhídvég	**987**	**1345**	100,0	987	15,8	39,4	13,5	0,9	4,1			x			Hernad	3
Selyeb	488	1664	100,0	488	7,8	19,5	6,7	0,4	2,0		x			23	Servel,Vadasz-p-Vadasz patak	6
Sóstófalva	236	731	100,0	236	3,8	9,4	3,2	0,2	1,0		x		1			6
Szakácsi	127	863	100,0	127	2,0	5,1	1,7	0,1	0,5		x		1	31	Vadasz-Patak	6
Szalaszend	**1129**	**1822**	100,0	1129	18,0	45,1	15,5	1,0	4,7		x			27	Belus-P	19
Szemere	418	2629	100,0	418	6,7	16,7	5,7	0,4	1,7		x			44	Belus-P	19
zentistvánbaks	338	656	100,0	338	5,4	13,5	4,6	0,3	1,4		x				Hernad	15
Szikszó	**6110**	**3620**	92,5	5650,82	90,2	225,6	77,3	4,9	23,5		x			6	Vadasz	6
Telkibánya	657	4682	100,0	657	10,5	26,2	9,0	0,6	2,7	Up. Hld.				10	Czencko-P	-5
Tomor	291	1289	100,0	291	4,6	11,6	4,0	0,3	1,2		x			24	Vadasz	6
Tornyosnémeti	647	1404	100,0	647	10,3	25,8	8,9	0,6	2,7	Up. Hld.				3	Szartos-p	Via Szartos reservoi
Ujcsalános	737	1218	100,0	737	11,8	29,4	10,1	0,6	3,1		x			3		6
Vizsoly	**929**	**1844**	100,0	929	14,8	37,1	12,7	0,8	3,9	x					Hernad	0
Zsujta	213	673	100,0	213	3,4	8,5	2,9	0,2	0,9	Up. Hld.				1	Czenko-p	-5
SUM, 71	64319	101718	94,5	60788,8	970,7	2426,8	832,0	52,7	252,9							
SUM, 20	45653	43063	92,3	42122,8	672,6	1681,6	576,6	36,5	175,3							
SUM20/sum72	70,979	42,3356731		69,2937	69,3	69,3	69,3	69,3	69,3							
Upstream Hld	2081	8792	100,0	2081	33,2	83,1	28,5	1,8	8,7							
Sum Vizoly	9193	17550	98,4	9043,65	144,4	361,0	123,8	7,8	37,6							
Sum Geztely	39429	63423	91,9	36238,6	578,7	1446,7	496,0	31,4	150,8							
Sum mouth	13616	11953	98,6	13425,5	214,4	536,0	183,8	11,6	55,9							
SUM	64319	101718	94,5	60788,8	970,7	2426,8	832,0	52,7	252,9							

Table A4. Sewage loads from wastewater treatment plants.

	Popul.	Area	Public sewage				Treatment System		Public sewage after treatment, domestic					Public sewage, after treatment, Industry					Total estimated loads, municipalities and Industry					Recipientarea		
		km2	Connec	Pop	Q dom.	Qind	Mech.%	Biol	BOD	COD	SS	Tot-P	Tot-N	BOD	COD	SS	Tot-P	Tot-N	BOD	COD	SS	Tot-P	Tot-N	Vizoly	Geztely	Mouth
Abaújszolnok	134	865																							x	
Abaújvár	309	732																						Up. Hld.		
Alsódobsza	377	1070																							x	
Alsógagy	142	628																							x	
Alsóvadász	**1477**	**2291**																							x	
Aszaló	**1960**	**2536**																							x	
Baktakék	767	1881																							x	
Beret	226	678																							x	
Berzék	933	1060																								x
Böcs	**2643**	**2432**	7,2	190,51	102,7	0,3		100	1,304	3,26	0,869	0,122	0,626	0,004	0,01	0,003	0,00036	0,002	1,31	3,27	0,872	0,122	0,628			x
Csenyéte	276	997																							x	
Csobád	721	1185																							x	
Detek	313	968																							x	
Encs	**6663**	**3113**	41,0	2731,2	113	64,3		100	18,69	46,73	12,46	1,745	8,972	10,64	26,59	7,091	0,99269	5,105	29,3	73,3	19,55	2,737	14,08		x	
Fancsal	365	977																							x	
Felsôdobsza	914	1519																							x	
Felsôgagy	170	1447																							x	
Felsôvadász	525	1864																							x	
Forró	**2239**	**1901**																							x	
Fulókércs	327	1859																							x	
Gadna	253	809																							x	
Gagyapáti	18	322																							x	
Garadna	425	974																						x		
Gesztely	**2753**	**2882**																							x	
Gönc	**2378**	**3726**	5,0	117,75	6,1	11,7	100		1,88	4,701	1,074	0,091	0,438	3,606	9,016	2,061	0,17517	0,841	5,49	13,7	3,135	0,266	1,279	x		
Göncruszka	714	1669																						x		
Halmaj	**1761**	**1259**																							x	
Hangács	693	2255																							x	
Hegymeg	133	570																							x	
Hejce	298	951																						x		
Hernádbüd	166	592																							x	
Hernádkak	**1036**	**1090**																								x
Hernádkércs	325	742																							x	
Hernádnémeti	**3598**	**2876**																								x
Hernádpetri	235	1707																						x		
Hernádszentandrás	357	699																							x	
Hernádszurdok	253	436																						x		
Hernádvécse	**851**	**1689**																						x		
Hidasnémeti	**1167**	**1618**	2,7	31,597	3,4	38,2	49	51	0,358	0,894	0,215	0,022	0,111	4,017	10,04	2,413	0,25057	1,242	4,37	10,9	2,628	0,273	1,353	x		
Homrogd	**987**	**1343**																							x	
Ináncs	**1167**	**1095**																							x	
Irota	157	1233																							x	
Kéked	255	1301																						Up. Hld.		

Table A4. Sewage loads from wastewater treatment plants.																										
	Popul.	Area	Public sewage				Treatment		Public sewage					Public sewage, after					Total estimated loads,					Recipientarea		
							System		after treatment, domestic					treatment, industry					municipalities and industry					Vizoly	Geztely	Mouth
Kiskinizs	322	718																							x	
Korlát	343	791																						x		
Kupa	199	784																							x	
Lak	548	1976																							x	
Léh	478	843																							x	
Litka	72	670																							x	
Monaj	227	1153																							x	
Nagykinizs	373	657																							x	
Novajidrány	**1399**	**1431**																						x		
Nyésta	78	689																							x	
Onga	**4419**	**3150**																								x
Pere	456	953																							x	
Pusztaradvány	201	714																						x		
Rásonysápberencs	436	908																							x	
Sajóhídvég	**987**	**1345**																								x
Selyeb	488	1664																							x	
Sóstófalva	236	731																							x	
Szakácsi	127	863																							x	
Szalaszend	**1129**	**1822**																							x	
Szemere	418	2629																							x	
Szentistvánbaksa	338	656																							x	
Szikszó	**6110**	**3620**	7,5	459,18	28,4	68,5		100	3,143	7,856	2,095	0,293	1,508	7,58	18,95	5,053	0,707	3,638	10,7	26,8	7,148	1,001	5,147		x	
Telkibánya	657	4682																						Up. Hld.		
Tomor	291	1289																							x	
Tornyosnémeti	647	1404																						Up. Hld.		
Ujcsalános	737	1218																							x	
Vizsoly	**929**	**1844**																						x		
Zsujta	213	673																						Up. Hld.		
SUM, 71	64319,0	101718	5,5	3530,2	253,6	183,0	5,0	95,0	25,4	63,4	16,7	2,3	11,7	25,8	64,6	16,6	2,1	10,8	51,2	128,0	33,3	4,4	22,5			
SUM, 20	45653,0	43063,0	7,7	3530,2	253,6	183,0			25,4	63,4	16,7	2,3	11,7	25,8	64,6	16,6	2,1	10,8	51,2	128,0	33,3	4,4	22,5			
SUM20/sum72	71,0	42,3		100,0	100,0	100,0			100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0			
Upstream Hld	2081,0	8792,0	0,0	0,0	0,0	0,0			0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0			
Sum Vizoly	9193,0	17550,0	1,6	149,3	9,5	49,9			2,2	5,6	1,3	0,1	0,5	7,6	19,1	4,5	0,4	2,1	9,9	24,7	5,8	0,5	2,6			
Sum Geztely	39429,0	63423,0	8,1	3190,4	141,4	132,8			21,8	54,6	14,6	2,0	10,5	18,2	45,5	12,1	1,7	8,7	40,0	100,1	26,7	3,7	19,2			
Sum mouth	13616,0	11953,0	1,4	190,5	102,7	0,3			1,3	3,3	0,9	0,1	0,6	0,0	0,0	0,0	0,0	0,0	1,3	3,3	0,9	0,1	0,6			
SUM	64319,0	101718,0	5,5	3530,2	253,6	183,0			25,4	63,4	16,7	2,3	11,7	25,8	64,6	16,6	2,1	10,8	51,2	128,0	33,3	4,4	22,5			

Table A5. Water quality status and and water quality objectives in different river profiles.

Profile	BOD 5						COD - Mn						N - NH4						N - NO2					
	C90	Obj1	Obj2	Obj3	Obj4	Obj5	C90	Obj1	Obj2	Obj3	Obj4	Obj5	C90	Obj1	Obj2	Obj3	Obj4	Obj5	C90	Obj1	Obj2	Obj3	Obj4	Obj5
Hidasnemeti	8,80			3	6	4	7,69			10	8	5	3,90	0,05	0,05	0,04	0,50	0,20	0,36	0,01	0,01	0,01	0,03	0,01
Vizoly			3,00	3	6	4			10,00	10	8	5		0,05	0,04	0,04	0,50	0,20		0,01	0,01	0,01	0,03	0,01
Gesztely	7,77		3	3	6	4	6,44		10,00	10	8	5	2,44	0,05	0,04	0,04	0,50	0,20	0,14	0,01	0,01	0,01	0,03	0,01
Mouth		3	3	3	6	4		10,00	10,00	10	8	5		0,04	0,04	0,04	0,50	0,20		0,01	0,01	0,01	0,03	0,01
Belus-patak					6	6	97,32			10	8	8	57,94	0,05	0,05	0,05	0,50	0,50		0,01	0,01	0,01	0,03	0,03
Gonci-patak					6	6	48,96			10	8	8	30,60	0,05	0,05	0,05	0,50	0,50		0,01	0,01	0,01	0,03	0,03
Vadasz-patak					6	6	82,08			10	8	8	100,32	0,05	0,05	0,05	0,50	0,50		0,01	0,01	0,01	0,03	0,03
Hernad Uzenviz Csatorna					6	6	24,48			10	8	8	8,73	0,05	0,05	0,05	0,50	0,50		0,01	0,01	0,01	0,03	0,03
Barsonyos Csatorna A					6	6	15,68			10	8	8	1,05	0,05	0,05	0,05	0,50	0,50		0,01	0,01	0,01	0,03	0,03
Barsonyos Csatorna B					6	6				10	8	8	89,11	0,05	0,05	0,05	0,50	0,50		0,01	0,01	0,01	0,03	0,03

	N - NO3						P - PO4						Tot - P.						Hg					
	C90	Obj1	Obj2	Obj3	Obj4	Obj5	C90	Obj1	Obj2	Obj3	Obj4	Obj5	C90	Obj1	Obj2	Obj3	Obj4	Obj5	C90	Obj1	Obj2	Obj3	Obj4	Obj5
Hidasnemeti	4,1			5,65	5	1	0,49			0,18	0,05	0,02	0,57			1,00	0,10	0,04	0,28	0,50	0,50	0,50	0,20	0,10
Vizoly			5,65	5,65	5	1			0,18	0,18	0,05	0,02			1,00	1,00	0,10	0,04		0,50	0,50	0,50	0,20	0,10
Gesztely	4,5		5,65	5,65	5	1	0,42		0,18	0,18	0,05	0,02	1,70		1,00	1,00	0,10	0,04	0,21	0,50	0,50	0,50	0,20	0,10
Mouth		5,65	5,65	5,65	5	1		0,18	0,18	0,18	0,05	0,02		1,00	1,00	1,00	0,10	0,04		0,50	0,50	0,50	0,20	0,10
Belus-patak	58,9				5	5					0,05	0,05					0,10	0,10		0,50	0,50	0,50	0,20	0,20
Gonci-patak	1,2				5	5					0,05	0,05					0,10	0,10		0,50	0,50	0,50	0,20	0,20
Vadasz-patak	54,0				5	5					0,05	0,05					0,10	0,10		0,50	0,50	0,50	0,20	0,20
Hernad Uzenviz Csatorna	12,2				5	5					0,05	0,05					0,10	0,10		0,50	0,50	0,50	0,20	0,20
Barsonyos Csatorna A	10,9				5	5					0,05	0,05					0,10	0,10		0,50	0,50	0,50	0,20	0,20
Barsonyos Csatorna B	11,5				5	5					0,05	0,05					0,10	0,10		0,50	0,50	0,50	0,20	0,20

	Cd						Ni						Zn						Pb					
	C90	Obj1	Obj2	Obj3	Obj4	Obj5	C90	Obj1	Obj2	Obj3	Obj4	Obj5	C90	Obj1	Obj2	Obj3	Obj4	Obj5	C90	Obj1	Obj2	Obj3	Obj4	Obj5
Hidasnemeti	3,00	3	3	1	1	0,50	25,88	20	20	20	30	15	140,0	200	200	200	75	50	25,80	50	50	50	20	5
Vizoly		3	1	1	1	0,50		20	20		30	15		200	200	200	75	50		50	50	50	20	5
Gesztely	2,29	3	1	1	1	0,50	28,19	20	20	20	30	15	114,4	200	200	200	75	50	25,00	50	50	50	20	5
Mouth		1	1	1	1	0,50		20	20	20	30	15		200	200	200	75	50		50	50	50	20	5
Belus-patak		3	3	3	1	1		20	20	20	30	30		200	200	200	75	75		50	50	50	20	20
Gonci-patak		3	3	3	1	1		20	20	20	30	30		200	200	200	75	75		50	50	50	20	20
Vadasz-patak		3	3	3	1	1		20	20	20	30	30		200	200	200	75	75		50	50	50	20	20
Hernad Uzenviz Csatorna		3	3	3	1	1		20	20	20	30	30		200	200	200	75	75		50	50	50	20	20
Barsonyos Csatorna A		3	3	3	1	1		20	20	20	30	30		200	200	200	75	75		50	50	50	20	20
Barsonyos Csatorna B	90	3	3	3	1	1	87	20	20	20	30	30	77,4	200	200	200	75	75	4,00	50	50	50	20	20

	Cu						Mn						Fe					
	C90	Obj1	Obj2	Obj3	Obj4	Obj5	C90	Obj1	Obj2	Obj3	Obj4	Obj5	C90	Obj1	Obj2	Obj3	Obj4	Obj5
Hidasnemeti	19,88	200	200	20	10	5	0,31	0,20	0,20	0,05	0,10	0,05	2,28	1	1	0,1	0,2	0,1
Vizoly		200	20	20	10	5		0,20	0,05	0,05	0,10	0,05		1	0,1	0,1	0,2	0,1
Gesztely	14,34	200	20	20	10	5	0,30	0,20	0,05	0,05	0,10	0,05	1,99	1	0,1	0,1	0,2	0,1
Mouth		20	20	20	10	5		0,05	0,05	0,05	0,10	0,05		0,1	0,1	0,1	0,2	0,1
Belus-patak		200	200	200	10	10		0,20	0,20	0,20	0,10	0,10		1	1	1	0,2	0,2
Gonci-patak		200	200	200	10	10		0,20	0,20	0,20	0,10	0,10		1	1	1	0,2	0,2
Vadasz-patak		200	200	200	10	10		0,20	0,20	0,20	0,10	0,10		1	1	1	0,2	0,2
Hernad Uzenviz Csatorna		200	200	200	10	10		0,20	0,20	0,20	0,10	0,10		1	1	1	0,2	0,2
Barsonyos Csatorna A		200	200	200	10	10		0,20	0,20	0,20	0,10	0,10		1	1	1	0,2	0,2
Barsonyos Csatorna B	51,00	200	200	200	10	10		0,20	0,20	0,20	0,10	0,10	6,64	1	1	1	0,2	0,2

Table A6. Costs for upgrading of sewage plants, inter municipal cooperation.

Loc.of WWTP	Technical solution	Municipalities	Pe Corr.	No of fla flat	Area (km km2	Qdimru rural m3/d	QExis	Qtotal m3/d	Qtotal l/s	Sewer Private km	Sewer Town km	Sewer Exist km	Sewer between km	Qdim	Costs NOK/M	Sewer Costs, inv	Sewer Costs, ann	WWTP Costs Investmе	WWTP Costs Inv.ann	WWTP Costs O&M	WWTP Annual	Total Annual Alt.1
Hidasnemeti	The Mechanical/biological WV	Hidasnémeti	1690	419	1618	227	114	341	3,9	6,3	4	1,2		5,4	500	4543	218					
	is to small. The building can	Tornyosnemti	647	257	1404	129		129	1,5	3,9	3		4	1,5	500	5428	260					
Qdim, WWTP	be used, 114		**2337**	**676**	**3022**			**470**	**5,4**	**10,1**	**7**		**4**			**9970**	**478**	**4822**	**385**	**80**	**465**	**943**
Göncruszka	The existing WWTP in Gønc i	Göncruszka	714	319	1699	143		143	1,7	4,8	5			7,5	500	4893	235					
	small, 80m3/d	Gönc	2538	929	3726	452	49	501	5,8	13,9	8	1,4	3	5,8	500	11768	564					
Qdim, WWTP	build a new one in Gøncruszka		**3252**	**1248**	**5425**	**595**	**49**	**644**	**7,5**	**18,7**	**13**		**3**			**16660**	**799**	**5602**	**442**	**110**	**552**	**1351**
Vizsoly	New	Vizoly	929	334	1844	186		186	2,2	5,0	5		2	8,3	500	6005	288					
		Hemádvécse	851	259	1689	170		170	2,0	3,9	4		2	2	500	4943	237					
		Garadna	425	180	974	85		85	1,0	2,7	2		2	3	500	3350	161					
		Novajidrány	1399	424	1431	280		280	3,2	6,4	3		5	6,2	500	7180	344					
Qdim, WWTP			**3604**	**1197**	**2405**	**721**		**721**	**8,3**	**9,1**	**5**		**7**			**21478**	**1030**	**5883**	**463**	**122**	**585**	**1615**
Encs	Upgrading of existting plant ar	Encs	7544	2181	3113	786	486	1272	14,7	32,7	12	18,7		14,7	600	12338	592					
	building of a new one	Szalaszend	1129	344	1822	226		226	2,6	5,2	4		8	2,6	500	8580	411					
Qdim, WWTP	1000m3/d,(67%),spare bygg		**8673**	**2525**	**4935**	**1012**	**486**	**1498**	**17,3**	**37,9**	**16**		**8**			**20918**	**1003**	**10408**	**766**	**275**	**1041**	**2044**
Felsôdobsza	New	Felsôdobsza	914	327	1519	183		183	2,1	4,9	3			10	600	4253	204					
		Forro	2239	670	1901	448		448	5,2	10,1	5		5	5,2	500	10025	481					
		Ináncs	1167	392	1095	233		233	2,7	5,9	3		4	7,9	500	6440	309					
Qdim, WWTP			**4320**	**1389**	**2996**	**864**		**864**	**10,0**	**15,9**	**8**		**9**			**20718**	**993**	**6228**	**488**	**147**	**636**	**1629**
Szikszó	Upgrading of existing plant an	Szikszó	7048	2129	3620	1130	266	1396	16,2	31,9	13	5,6		26,4	650	20778	996					
	building of a new one	Homrogd	987	314	1343	197		197	2,3	4,7	3		3	2,3	500	5355	257					
	452 (19%)	Alsóvadász	1477	439	2291	295		295	3,4	6,6	4		6	5,7	500	8293	398					
		Aszaló	1960	622	2536	392		392	4,5	9,3	4		6	4,5	500	9665	463					
		Halmaj	1761	572	1259	347		347	4,0	8,6	4		4	4	500	8290	397					
Qdim, WWTP			**13233**	**4076**	**11049**	**2361**	**266**	**2627**	**30,4**	**61,1**	**28**	**5,6**	**19**	**42,916**		**52380**	**2511**	**16380**	**1235**	**414**	**1649**	**4160**
Sajóhídvég	New, outlet to Sajo	Sajóhídvég	987	322	1345	197		197	2,3	4,8	4		3	40,7	700	7315	351					
		Onga	4419	1364	3150	884		884	10,2	20,5	9		6	10,2	600	19230	922					
		Gesztely	2753	884	2882	551		551	6,4	13,3	8		2	6,4	500	11630	558					
		Hernádkak	1036	365	1090	207		207	2,4	5,5	6		2	8,8	500	6738	323					
		Hernádnémeti	3598	1108	2876	720		720	8,3	16,6	10		3	27,3	650	16760	804					
		Böcs	2647	874	2432	490	282	772	8,9	13,1	8	1,2	3	36,2	700	13415	643					
		Berzék	933	327	1060	187		187	2,2	4,9	3		3	38,4	700	6653	319					
Qdim, WWTP			**16373**	**5244**	**3492**	**3236**		**3518**	**40,7**	**18,0**	**11**		**6**			**81740**	**3919**	**20148**	**1513**	**512**	**2025**	**5944**
Installat. of waste water treatment plant and training of operation personell 1																		500	67		67	67
SUM			**51792**	**16355**	**33324**	**8789**	**801**	**10342**	**119,7**	**170,9**	**88**		**56**			**223863**	**10733**	**69971**	**5359**	**1660**	**7020**	**17753**

Table A7. Costs for upgrading of sewage plants, Inividual plants.

Municipalities	Pe Corr.	No of flat	Area (km2)	Qdimrural	QExisting	Qtotalm3/d	Qtotal l/s	Lenght of privat sewer(km)	Length of sewer town(km)	Length existin sewer	Qdim	Costs NOK/M	Sewer Costs, in 1000NOK	Sewer Costs, an 1000 NOK	WWTP Costs Investme	WWTP Costs Inv.annu	WWTP Costs O&M	WWTP Annual	Total Annual C Alt.1
Hidasnémeti	1690	419	1618	227	114	341	3,9	6,3	4	1,2	5,4	500	4543	218	3528	327	58	385	603
Göncruszka	714	319	1699	143		143	1,7	4,8	5		7,5	500	4893	235	3000	251	36	287	521
Gönc	2538	929	3726	452	49	501	5,8	13,9	8	1,4	5,8	500	10268	492	5030	400	86	486	978
Vizoly	929	334	1844	186		186	2,2	5,0	5		8,3	500	5005	240	3000	251	36	287	527
Hernádvécse	851	259	1689	170		170	2,0	3,9	4		2	500	3943	189	3000	251	36	287	476
Novajidrány	1399	424	1431	280		280	3,2	6,4	3		6,2	500	4680	224	3638	298	49	347	571
Encs	7544	2181	3113	786	486	1272	14,7	32,7	12	18,7	14,7	600	12338	592	9053	666	243	909	1501
Szalaszend	1129	344	1822	226		226	2,6	5,2	4		2,6	500	4580	220	3206	266	40	306	526
Felsôdobsza	914	327	1519	183		183	2,1	4,9	3		10	600	4253	204	3000	251	36	287	491
Forro	2239	670	1901	448		448	5,2	10,1	5		5,2	500	7525	361	4687	375	76	451	812
Ináncs	1167	392	1095	233		233	2,7	5,9	3		7,9	500	4440	213	3267	271	41	312	525
Szikszó	7048	2129	3620	1130	266	1396	16,2	31,9	13	5,6	26,4	650	20778	996	8458	622	229	852	1848
Homrogd	987	314	1343	197		197	2,3	4,7	3		2,3	500	3855	185	3000	251	36	287	472
Alsóvadász	1477	439	2291	295		295	3,4	6,6	4		5,7	500	5293	254	3763	307	51	358	612
Aszaló	1960	622	2536	392		392	4,5	9,3	4		4,5	500	6665	320	4352	350	67	417	737
Halmaj	1761	572	1259	347		347	4,0	8,6	4		4	500	6300	302	4113	333	60	393	695
Sajóhídvég	987	322	1345	197		197	2,3	4,8	4		40,7	700	5215	250	3000	251	36	287	537
Onga	4419	1364	3150	884		884	10,2	20,5	9		10,2	600	15630	749	6268	491	151	642	1391
Gesztely	2753	884	2882	551		551	6,4	13,3	8		6,4	500	10630	510	5202	413	93	506	1016
Hernádkak	1036	365	1090	207		207	2,4	5,5	6		8,8	500	5738	275	3058	255	37	292	567
Hernádnémeti	3598	1108	2876	720		720	8,3	16,6	10		27,3	650	14810	710	5878	463	122	585	1295
Böcs	2647	874	2432	490	282	772	8,9	13,1	8	1,2	36,2	700	11315	543	4618	407	89	496	1039
Berzék	933	327	1060	187		187	2,2	4,9	3		38,4	700	4553	218	3000	251	36	287	505
Installat. of waste water treatment plant and training of operation personell 1															3200	235		235	235
SUM	50720	15918	47341	8931	1197	10128	117,206	238,8	132	28,1			177245	8498	102320	8236	1742	9979	18477

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