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Watman Phase II: Water Framework Directive

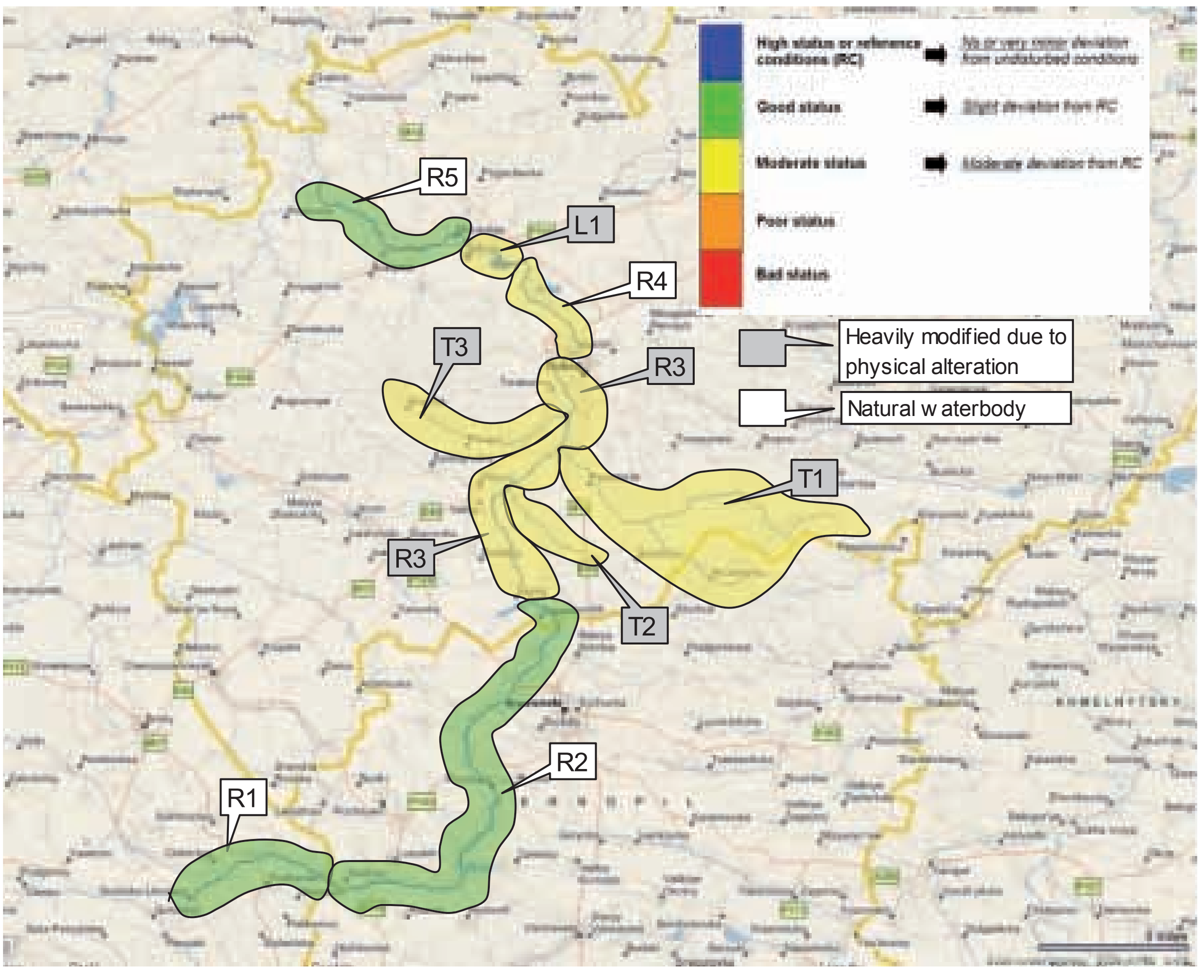
State Department for Environmental Protectection, Rivne Region

National University of Water Management and Natural Resources Use, Rivne

Institute of Hydrobiology, Kiev

Water Management Center, Lviv

Proposed organisation of Pripyat Water Region and characterisation of Ikva River - training workshops in Rivne, Ukraine, autumn 2009 and spring 2010



Norwegian Institute for Water Research
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REPORT

Main Office	Regional Office, Sørlandet	Regional Office, Østlandet	Regional Office, Vestlandet	Regional Office Central
Gaustadalléen 21 NO-0349 Oslo, Norway Phone (47) 22 18 51 00 Telefax (47) 22 18 52 00 Internet: www.niva.no	Jon Lilletuns vei 3 NO-4879 Grimstad, Norway Phone (47) 22 18 51 00 Telefax (47) 37 04 45 13	Sandvikaveien 41 NO-2312 Ottestad, Norway Phone (47) 22 18 51 00 Telefax (47) 62 57 66 53	Thormøhlens gate 53 D NO-5006 Bergen Norway Phone (47) 22 18 51 00 Telefax (47) 55 31 22 14	Pirsenteret, Havnegata 9 P.O.Box 1266 NO-7462 Trondheim Phone (47) 22 18 51 00 Telefax (47) 73 54 63 87

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Abstract

A series of work shops has been held at the State Department of Environmental Protection in Rivne, Western Ukraine 2009 and 2010. A proposal for organizing the Ukrainian part of Pripyat River into Water Region has been worked out, both with regard to geographical demarcation, as well as administrative adaptation to the Ukrainian water management units. The workshops have also delt with simulated training conductance of the work tasks in the Water Framework Directive, using the River Ikva as an example. This report presents the proposed organization of the Pripyat Water Region as well as the characterization of the Ikva River, monitoring programme and resusult, need for abatements, programme of measures, measure analysis and ranking.

4 keywords, Norwegian	4 keywords, English
1. Vanndirektivet	1. Water Framework Directive
2. Organisering	2. Organization
3. Treningskurser	3. Training work shops
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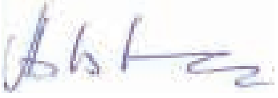
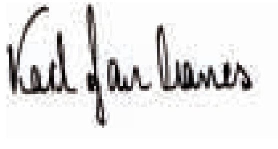


Harsha Ratnaweera
Project manager

Karl Jan Aanes
Research manager

Brit Lisa Skjelkvåle
Research Director

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Norwegian Institute for Water Research
Oslo
State Department of Environmental Protection
Rivne

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Watman Phase II: Water Framework Directive

Proposed organisation of Pripyat Water Region and characterisation of Ikva River - training workshops in Rivne, Ukraine, 2009 and 2010

Oslo, Rivne 3.12.2010

Project leader	Harsha Ratnaweera	NIVA
Co-workers	Dag Berge	NIVA (main author of the report)
	Petro Kolodych	Min. Env. Prot. Ukr., Dept. Rivne
	Solomiya Stefanyshyn	Water Management Center
	Oksana Manturova	Inst. Hydrobiol., Kiev
	For more Ukrainian participants, see list in the preface	

Preface

This report presents the results of the workshops in Rivne in 2009 – 2010 on training and organizing of the regional water management according to the principles in the Water Framework Directive. More specifically the report deals with organizing the Pripyat Water Region in Ukraine, and the characterization, monitoring, environmental goals, abatement measures of Ikva River, a secondary tributary to the Pripyat River.

The project constitutes Phase II of the Watman Project, and is a co-operation between Norwegian Institute for Water Research and several Ukrainian institutions, see list below. The contractors are the Norwegian Ministry of Foreign Affairs and the Ukrainian Ministry of Environmental Protection.

The client, and main co-operation partner is the State Department of the Environmental Protection in the Rivne region, headed by Mr. Petro Kolodych. He has been responsible for the work with organizing the Pripyat Water Region, as well as organizing the workshops in an excellent way. From the Institute of Hydrobiology Dr. Oksansa Manturova has been the main responsible for the work on hydro-biological inputs, evaluations and assessments on the Ikva River, as well as coordinating the inputs from other hydro biologists. CEO of the Water Management Center (WMC), Ms. Solomiya Stefanyshyn, has been our main practical co-operator, organizer and facilitator in the project, as well as translated all documents in both directions. Her skillful and efficient contribution has been of decisive importance for the success of this project.

The project leader for the NIVA part of the Watman Project is Dr. Harsha Ratnaweera. His topical input to Phase II has been on the organization of the Pripyat Water Region. Senior Scientist Dag Berge has been the main contributor from NIVA on the Phase II of the Watman Project. He has lead the topical parts of all the workshops, giving advice to the Ukrainian partners, compiled their contributions into the report, as well as written most of the report. Senior Scientist Torleif Bækken, and Head of Water Management Dept at NIVA, Karl Jan Aanes has also contributed with inputs on how the WFD handle biological material to assess the ecological status. The Ukrainian participants are given in the list below:

Kolodych Petro Danylovych	*Head of the State department of the environmental protection in Rivne region*
Chub Volodymyr Ivanovych	*Vice Head of the State department of the environmental protection in Rivne region*
Prachuk Oleksandr Sergiyovych	*Head specialist of the department of the complex management and regulations of the state department of the environmental protection in Rivne region*
Kurylchyk Oleksandr Illich	*Head of the department of the complex management and regulations of the state department of the environmental protection in Rivne region*
Mantula Maryna Valentynivna	*Leading specialist of the department of the state ecological expertise, monitoring and public relations of the State department of the environmental protection in Rivne region*
Yakovlev Yuriy Yegorovych	*Head specialist of the department of the complex management and regulations of the state department of the environmental protection in Rivne region*

Kolodych Oleg Danylovych	*Head of the Rivne regional hydro meteorological center*
Kondratiuk Tetiana Vasylivna	*Head of the department of the instrumental and laboratory control of the state ecological inspection of the Rivne region*
Klima Tetiana Ambrosiivna	*Vice head of the department of the instrumental and laboratory control of the state ecological inspection of the Rivne region*
Zalesky Ivan Ivanovych	*PhD in Geography, docent of the ecology chair NUWR*
Klymenko Mykola Oleksandrovych	*Head of the ecology chair of the National university of water resources NUWR, prof Agricultural sciences,*
Sondak Vasyl Volodymyrovych	*Docent, PhD in biology.*
Veremeenko Sergij Ivanovych	*Head of the chair of agro chemistry, soils and agriculture, Prof, PHD in agriculture sciences*
Rokochynsky Anatoliy Mykolayovych	*Head of the chair of the hydro melioration, NUWR , professor, post doc in technical sciences*
Moshynsky Viktor Stepanovych	*Professor of the Chair of agriculture, geodesy and geo information of NUWR*
Antoniuk Vasyl Myhailovych	*Director директор КП "Dubnovodokanal"*
Stefanyshyn Solomiya	*Water Management Center*
Chuhrai Sviatoslav	*Water Management Center*
Kyrychenko Valentyna	*Water Management Center*
Rushchak Dmytro	*UNDP/GEF Dnjipro Basin Environment Programme*
Manturova Oksana	*Institute of Hydrobiology, Kiev*
Slobodyan Bogdan	*Geological Inspection "Pivnichgeologia" in Rivne Oblast*
Salo Bohdan	*Head of Complex laboratory on research of the natural environment state contamination*
Zinchuk Ludmyla	*Director of the Sector on Surface Waters*
Yatsenya Lyudmyla	*Senior epidemiologist of the State Department on Health Care in Rivne Oblast*
Gushchuk Igor	*Deputy Senior Doctor of Sanitary Epidemiological Service in Rivne Oblast*
Vengrovskyi Victor	*Representative of Mlyniv District State Administration*
Kovalitskyi Bogdan	*Head of Department of State Committee for land resources in Rivne Oblast*

Masnitskyi Valentyn	*Representative of State Department on protection, use and recovery of aquaculture and fishing regulation in Rivne oblast.*
Datsenko Vitalyi	*Deputy Head of State Department on melioration and water management in Rivne oblast*
Gerasymchuk Volodumur	*Head of State Department on Water Management in Dubno district*
Bronskiy Borus	*Head of the Department of State Committee for land resources in Dubno District*
Iryna Iarema	*Ministry of Environmental Protection of Ukraine*

Oslo, 3.12. 2010

Harsha Ratnaweera
Project leader

Contents

1. Summary

1.1 Aims

The aims of Phase II of the Watman Project are two-fold:

1. Assist in organizing Pripyat Water Region in Ukraine in the WFD-manner with State Department of Environmental Protection in Rivne as Competent Authority.
2. Perform a series of training workshops in Rivne for the staff that will be dealing with this new kind of water management. Ikva River (a secondary tributary to Pripyat River) is used as example-river for the training.

This report deals with point 1 Organizing Pripyat Water Region, as well as part of point 2: Namely the tasks included in the WFD which is called the “characterization”, status assessment, environmental goals, monitoring and abatement measures. The work is covered by 4 workshops in held in the City of Rivne, Western Ukraine, two workshops in the autumn 2009, and two in 2010. The work has been performed as much as possible as a "learning by doing" exercise. NIVA has given lessons and instructions for the different tasks. In the time between the workshops the Ukrainian experts have collected and compiled the material. In the workshops the Ukrainian experts has presented their material, where after we together discussed the findings, identified gaps, and draw the conclusions. The material that is compiled in this report is partly written by the Ukrainian team members and partly by the Norwegian team members.

1.2 Organizing the Pripyat Water Region

A proposal for the organization of the Ukrainian Pripyat Water Region has been outlined. The geographical area comprise all the Ukrainian parts of the Pripyat River catchment which consist of several unconnected tributaries running north and crossing the border to Belarus before entering the mainstream Pripyat River. Under the Water Region level the area is divided into five Water Areas: 1) The Mala Pripyat River Water Area, 2) The Styr River Water Area, 3) The Goryn River Water Area, 4) The Stygva/Ubort River Water Area, and 5) The Uzh River Water Area.

The administrative unit responsible for the Water Region (Competent Authority required by EU) is proposed to be the State Department of the Environmental Protection in the Rivne region, for the time being headed by Mr. Petro Kolodytch. In each of the Water Areas there are established a Water Area Office headed by a Water Area Coordinator, located to one of the Rayon administrations in the Water Area. Under the Water Area coordinator is a Water Area Council consisting of personnel from the different Rayon administrations and other units inside the Water Area with water management responsibility. The NGO’s and lay people is organized in a reference group and has the right to comment on plans, programmes, etc at special meetings or public hearings. At the Water Region level there is also established a Water Region Council to assist in the regional water management. This consists of the Water Area coordinators and other important water management representatives from the region. It is important that the different sectors with water management and water use interests are represented, as e.g. drinking water branch, agriculture authorities etc., in addition to the environmental authorities. At the Water Region level the NGOs shall also have the right to comment on plans etc., and it is also here established a Reference group in the same way as at the Water Area level.

The Water Region leader makes plans for what to do the next years, and gives instruction to the Water Area coordinators what to do. Most of the practical water management work is done in the Water Areas. This work is compiled up to Water Region level by the competent authority and reported to the national level, which report it further to the international Dnjepr River Basin competent authority, who compile the Dnjepr River Basin Water Management Plan and report this to the EU Commission. A water management plan should be made for each tributary above a certain size that the local administration thinks is a logical and practical water management unit. These small plans are compiled upwards to Pripyat Water Region level, the further up to the International Pripyat River Basin level, and at last up to the International Dnjepr River Basin level, which complete the water management plan. The idea is that if all upstream water bodies are kept in good ecological status, then even the lower stretches of the Dnjepr River will be in good ecological status.

1.3 Characterization of the Ikva River

The main aim of the characterization is to divide the river into definite water bodies that can act as practical water management units, and to assess which of these are at risk of not meeting the WFD-requirement of good ecological status.

Ukraine has not developed a typology system according to the prescriptions in the WFD. Therefore, for demonstration purposes we had to use a reduced "constructed" system. In this first characterization it is anticipated that the countries use their existing water quality classification system to assess the status of the water bodies, as they have not yet developed/adapted a WFD classification system.

The Ikva River has a catchment of 2250 km^2, and starting in the Lviv Oblast. The river runs through Ternopil Oblast before it enters the Styr River in the Rivne Oblast. No accurate land use mapping is done on the catchment basis, but roughly judged from available statistics from the Mlyniv Rayon and the Dubno Rayon about 70-80% of the catchment is agricultural land, 20 % is forest areas, and the rest being residential areas or bogs/wetlands/unproductive floodplains.

The population of the catchment is about 90 000 people. There are 3 towns (Dubno, Mlyniv, Kremenetz) and approximately 10 villages. The rest of the population lives in scattered settlements.

The catchment is heavily drained for agricultural land reclamation, particularly in the Dubno area and first fifteen km upstream, an area called the Ikva Drainage System. There is one large dam, constituting the Mlyniv Lake (or Mlyniv Reservoir), and a couple of dams in the Dubno area.

Important pollution point sources are the sewage discharge from the three town's treatment plants. These are old and have only removal or organic material, and no P or N removal. The villages and scattered settlements have no sewage treatment. With respect to industry, a sugar factory is the largest polluter. In the catchment there are also some animal husbandry farms which are not taking properly care of the manure, and which lead to pollution of both the surface water and the ground water. The use of nitrogen has resulted in nitrate pollution of the ground waters in some areas. Pesticides are also thought to pollute the ground water. The drainage and reclamation has resulted in lowering of the ground water by 1-2 m. This has accomplished oxidation of the organic soils, and a leaching of salts to the deeper ground water. The desertification of the top salts has lead to soil compaction. In some parts of the catchment there is peat extraction, which impacts the waters with respect to turbidity, and brownish stained humic material. Fish farming in ponds are also impacting the river, both by pollution, but also by damming and braking of the river continuum.

The ground waters are evenly distributed over the whole catchment, and are so far being regarded as one single water body.

The Ikva River and catchment is divided into 9 water bodies. 4 of these are regarded as natural water bodies, while 4 art regarded as heavily modified by physical alteration. The two uppermost stretches (water bodies) of Ikva River are regarded as being in good ecological status. The same applies for the river stretch downstream of Lake Mlyniv. In the mid section of the river the water bodies are regarded as being in moderate ecological status. This is both due to pollution impacts and impacts from heavily drainage (polder systems), damming, and straightening. The Mlyniv Lake is also regarded as being in moderate ecological status. These mid river water bodies (two main river stretches, three tributaries, and Mlyniv Lake) are regarded as being at risk of not meeting the WFD requirement of good ecological status. The others are regarded as not at risk.

There are proposed abatement measures for the water bodies that are poorer than good ecological status, and they are given a simplified cost-benefit analysis with the purpose of ranking the measures. There is, however, very little done with regard to ecological studies in the river, so the characterization results should be validated by practical studies before any decisions are taken about abatement measures.

2. Introduction

The aims of Phase II of the Watman Project are two-fold:

3. Assist in organizing Pripyat Water region in Ukraine in the WFD-manner with State Department of Environmental Protection in Rivne as Competent Authority.
4. Perform a series of training workshops in Rivne for the staff that will be dealing with this new kind of water management. Ikva River (a secondary tributary) is used as example-river for the training.

Figure 1 (grey field) shows the approximate geographical delineation of the Pripyat Water Region.

Figure 1. Geographical delineation of the Pripyat Water Region in Ukraine (Map from www.demis.nl)

This report deals with the so called first characterization of Ikva River, as well as looking into the next steps of the wfd-work tasks like, environmental goal, monitoring, and abatement measure planning. Ikva River is a small secondary tributary to the Pripyat River. It runs into Styr River, which runs into Pripyat River. Characterization is the first of the practical water management task that shall be performed after the country has been organized into river basin districts (also called Water Regions) and the Competent Authorities have been appointed.

The main aim of the characterization is to divide the watercourses into manageable water bodies, and to find out which of them are at risk of not being in good ecological status. In the first characterization most national WFD work-tools, like typology, classification system, etc., are not yet developed. This means that a nation has to base their status and risk assessment on its existing water quality criteria system. Monitoring shall be used to validate the impact assessment done in the characterization. The ecological status should be evaluated after a scale from 1-5, where 1 is the best and 5 the poorest. The water bodies should be managed in such a way that their ecological status is in the two best classes. If the status is moderate or poorer, rehabilitation measures has to be taken to bring the status back to class 1 or 2.

1. High ecological status (almost natural background levels)
2. Good ecological status (only slight deviation from natural conditions)
3. Moderate ecological status (clear impacts are seen, but still moderate disturbances on the ecology)
4. Poor ecological status
5. Bad ecological status

Each water region has to deliver a first characterization report 4 years after the WFD is implemented covering all the water bodies in the Water Region. However, the practical work is performed in much smaller water areas, in areas that are normally regarded as a natural management unit. This often goes down to each single river like Ikva. The characterization results from these smaller units are compiled to constitute the characterization report for the water region.

In this report we will compile the characterization tasks that have been carried out in the workshops in Rivne in the autumn 2009, as well as monitoring and abatement measure planning dealt with in workshops in 2010. This is not a complete Report in WFD terms as it is not possible to carry out all the tasks in just a few training workshops. It should be regarded as the outcome of a training course. However, the data is compiled, and evaluated, by skilled water experts with due knowledge of the river and its catchment. This means that the results would most likely not have been very different if this has been the official first characterization of the Ikva River.

3. Proposal for organization of the Ukrainian Pripyat River Basin District (or Pripyat Water Region as we prefer to call it)

This chapter is the results of the discussions between NIVA and the State Department of the Environmental Protection in Rivne Region. NIVA has instructed about the requirements from EU and how the organization has been done in Norway and other EU countries, while Mr. Petro Kolodych (Head of Dept) and his staff has proposed how this can fit into the Ukrainian water management system with particular emphasis on the Ukrainian area that drain to the Pripyat River, here called the Pripyat Water Region.

3.1 Names of the units

Several countries, among them the Scandinavian countries, have called the River Basin Districts for Water Regions and the sub-basins for Water Areas. A River Basin District in the WFD-notation, should comprise the whole river catchment and the marine influence area. It will be the Dnepr River Basin District which is the true basin scale management unit, see **Figure 2**. This will be highly international. The Pripyat River Basin District will also be international, and a sub-basin to the Dnjepr. On the Ukrainian scale the Pripyat basin contains several un-connected side branches of tributaries. It is more easily perceived to put these in under the name Water Region than River Basin District. The same applies for the sub-basins which are also not complete basins but often a bunch of not connected branches. Water Areas are more easily perceived as a name for these than Sub-Basin. The fact that the types of water bodies included are in addition to rivers, lakes and ground water aquifers, is also more easily perceived under names Water Regions and Water Areas. WFD accept that it is used different names on the subdivisions of the true river basin.

So for simplicity reasons, from here onwards we use the notation Pripyat Water Region of Ukraine for the large unit and Water Area for the smaller units.

Figure 2. Pripyat Water Region of Ukraine and its relation to the Dnjepr River Basin District

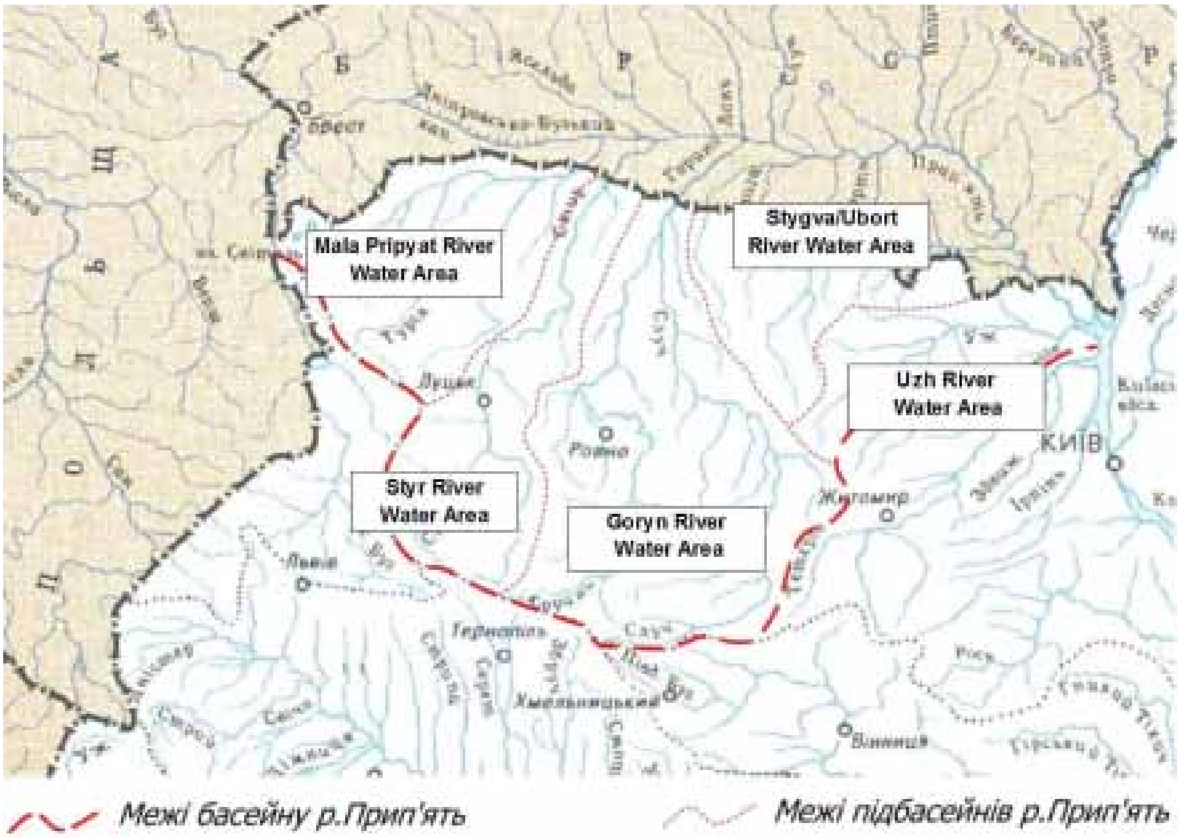

Figure 3. Pripyat Water Region of Ukraine and its division into Water Areas

3.2 WFD related Organization

What the WFD requires is that the water management is done on a whole river basin scale. The upstream countries or regions should not be allowed to us up all the recipient capacity of the river rendering a heavily polluted river to those who live along the downstream stretches. You should divide your country into Water Regions. Each Water Region can contain one or more river basins, or parts of international river basin. The outer boundaries of the Water Region should however, go along catchment borders. In each Water Region WFD requires appointment of a competent Water Region Authority, which for Pripyat Water Region is proposed to be the State Department of Environmental Protection in Rivne headed by Mr. Petro Kolodych. This Water Region must contain the whole catchment of Pripyat River in Ukraine. It cannot contain only part of it. However, it may contain more, if that is found practical for the water management. For example more of the smaller rivers draining to Dnjepr just south of the entrance of Pripyat into Dnjepr could be included if that fits better to the existing administrative units in Ukraine. However, this should be an own Water Area (sub-basin).

WFD does not set any rules for the sub-division into water areas. All countries have, however, found it practical to perform a subdivision. This should be done in the best practical way with respect to efficient water management. In this project we have found that it would be practical to divide the Pripyat Water Region into the five Water Areas as shown in **Figure 3**.

The implementation of the WFD should be possible to perform within the existing management entities in a country. In the Water Area it is not necessary to establish an own authority with it's own employees. It is enough with a Water Area Council headed by a coordinator. One of the municipalities (Rayons), or other administrative unit with water management responsibility and experience within the Water Area, should be selected to lead and co-ordinate the work in the Water Area and the Council. They establish the Water Area Office. This will need a full time leader, the Water Area Coordinator. He will likely need a full time secretary. Otherwise this office will use the Water Area Council to assist in the water management work. The Water Area Council is mainly staffed by representatives from the different municipalities (Rayons) administrations within the Water Area. It may be that representatives from important units outside the municipality administrations also could participate, e.g. inter-municipal companies like canal companies with responsibility for gates and locks and water flow, large water works (drinking water supply), etc.. It is also common to include a few representatives from regional state departments in the Water Area. As far as possible one should use the existing administrative personnel in the Water Area to do the water management work, but the Water Area Office shall coordinate the work. The Water Area Council should secure that all the municipalities and water management authorities in the Water Area should have the possibility to influence and participate in the new WFD-related way of water management. The Water Area Council has meetings approximately 4 times a year in the upstart year, and more seldom after a few years.

The Water Area Coordinator prepares the cases that should be discussed on the meetings, and makes proposals for decisions, as well as organizes the practical work in Water Area in the coming period. One should try to agree upon decisions, but when disagreement arises, the case is brought up to the Water Region Authority for final decision.

It is the Water Region Authority that has the responsibility to report the work to the national water management level, which again has the responsibility to report to the European Commission according to the common schedule.

The WFD requires that the lay-man and NGO's, like water use organizations, nature conservancy associations, hunters and fishers associations, etc., also should have the possibility to say their opinion on how things are being done. But they don't have to sit in the Water Region Council or Water Area Council. Most countries have put them into a Reference Group which have the possibility to give comments to plans etc., for example in specially arranged meetings, or hearings, or often both. Normally they have most to say about the plans on the Water Area scale. The Water Area Council normally invites the Reference Group to a meeting once a year, and presents the planned water management work for the next period (plans). They thereafter lay out the plan documents on a certain web-site (or at the municipality hall in paper copy) and give the Reference Group 3 weeks to come with written comments. This will take care of the requirements for public participation and consultation.

It is the authorities that shall rule also after the implementation of the WFD, but the public should have the possibility to come with their opinion. In fact, sometimes they give very good advice.

The WFD requires also a co-operation between the environmental authorities and the sectors authorities with water management responsibility. Often many of these sectors are in the municipality administration, like an agricultural department, a technical department with responsibility for municipal drinking water supply, municipal sewage discharges, etc. Therefore, in many countries, the sector interests can be covered by participation from the municipalities. If, for example, a Water Area consists of 4 municipalities, you will need to have representatives from all 4 municipalities in the Water Area Council. Those with main responsibility for water management should be included from all municipalities. But you don't have to bring in the agricultural department from all the 4 municipalities. The agricultural representative can represent the agricultural sector for all 4 municipalities. There is no rule for the maximum number of people in the councils, but I would say that it should not be too many. In the Water Area Council I would say approximately 20-30 persons, and in the Water Region Council 30-50 persons are normal sizes in Norway. It is important that representatives from all local authorities and all the local water related sector authorities are represented in the Water Area Council. In Norway the local self governing units is called communes or municipalities. In Ukraine the self governing unit below the oblast level is called rayon, which is parallel to the Norwegian municipality.

The Water Region Council should have a parallel kind of representatives as the Water Areas, but from the Oblast level, i.e. the regional level. All the Water Area Coordinators should be included, as well as representatives from the water management entities from all the oblasts included in the Water Region. These should comprise both the regional located state departments, as well as representatives from the regional authorities (Oblast government). I believe that the last one is the planning authority on the Oblast level. The public and the NGO's should sit in a reference group, and be allowed to say their opinion and comment the plans etc, but they normally don't sit in the council. The reference group to the Water Region Council is representative from the NGO associations at the Oblast level.

Figure 4 gives a simplified flow chart on how the WFD-type of water management administration can be organized in Pripyat Water Region. Remember, it should be integrated as far as possible into your existing administration and decision making system. Notice that the Reference Groups are connected by dotted lines, which mean that they are not part of the decision making system, but they have the right to say their views and give their advices.

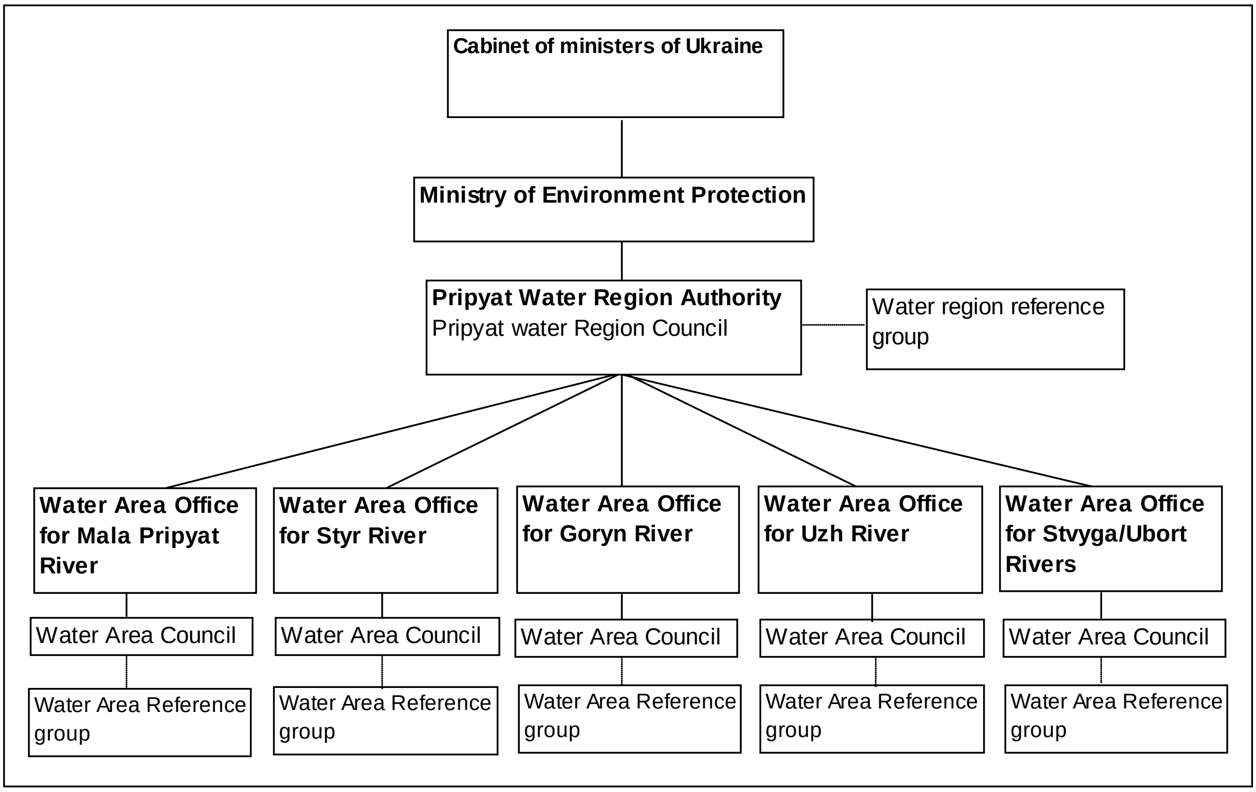

Figure 4. Proposed organization chart for the Pripyat Water Region with subdivisions into Water Areas. See text for more explanation.

3.3 Shortly about the Mandate of the Water Region Authority and the Water Region Council

It is the **Water Region Authority** that has the overall responsibility to ensure that the WFD work tasks are carried out within the water region in accordance with the given time schedule in the directive. The requirement for "participation" is taken care of by including the Water Region Council and reference group in a proper manner. The Water Region Authority makes outlines (work plans) for the WFD activities to be carried out in the region for each year. This includes detailed instructions to be carried out by the **Water Areas** constituting the Water Region as well. These plans are presented for, and discussed with, the Water Region Council. After agreement is achieved the work plans are set into operation. Most of the practical water management work will be done in the **Water Areas**. The Water Region Authority are giving them instruction of what to do, and are following up the work, to see that they are doing the work in due time. The Water Region Authority has the responsibility to compile the water management plans performed in the Water Areas to a Water Management Plan for the Water Region, and to report to the national level, so they can report to the European Commission in time.

In addition to these EU-requirements, it is practical to also add some of the national water management duties to the coordinating councils, in e.g. special cases that need coordination.

4. Description of Ikva River

4.1 General characteristics

The Ikva River (**Figure 5**) starts at the artesian springs near Chernytsya village of the Brody Rayon in the Lviv Oblast. Ikva River belongs to the River Styr basin, being its right tributary of the first order. It has its origin from the springs, which come out to the surface near the village Gubysko-Lytovske of Pid Kamin district Lviv Oblast at the height 368 m above the sea level. The river runs from the south to the north with the significant deviation to the east in the middle of the stretch and merges with the river Styr on the right bank at 283th km from the mouth near the village Torgovytsya in the Rivne Oblast at the height of 178,9 m above the sea level.

The river basin is located in the forest and forest – steppe zone. The length of the river is 148.8 km, water accumulation area – the catchment is 2250 km^2.

Within the boundaries of the Lviv Oblast the river has an east-west extent of 23 km with the narrow one-sided floodplain coming close to the southern bank. The stream bed does not meander in this part; it is 2.5-4.0 m in width, 0.5-1.7 m in depth. When the Ikva River enters the territory of the Ternopil Oblast, the actual elevation of water level is 267 m. The first tributary is near Lukashi village and the second tributary is in Tetelkivtsi village.

Figure 5. Location of Ikva River with approximate catchment in Rivne, Ternopil and Lviv Oblast in western Ukraine. The river is approximately 283 km long, and the total area of the catchment basin amounts to 2250 km^2.

In the territory of the Kremenestk Rayon (the Ternopil Oblast) the length of the Ikva River is 40 km. The river valley maintains its east-west direction up to Borshchivka village and then it abruptly turns north-northeast, and near the Shepetyn village it enters the administrative territory of the Dubnivskyi Rayon (the Rivne Oblast). The river valley expands at the point of entry of its first left tributary near Raslavka village and at the point of entry of its right tributary near Lopushne village. The floodplain becomes two-sided and reaches 350- 470 m. Starting from Borshchivka village, the Ikva River has formed its first stream terrace. The Ikva river valley spreads over 40 km on the territory of the Ternopil region.

Within the boundaries of the Dubnivksyi and Mlynivskyi Rayons (the Rivne Oblast) the length of the stream bed amounts to 93 km. 18 tributaries enter the Ikva River along the specified segment.
With respect to geomorphology the Ikva River basin covers part of the Podilian Upland, the Male Polissya and the Volynian Forest Upland. Total area of the catchment basin amounts to 2250 km^2, while on the territory of the Rivne region it is 400 km^2.

From the sources up to Kulykiv village of the Kremenetskyi Rayon the basin lies within the boundaries of the Podilian Upland. The river valley is relatively narrow up to 0.5 km. Lower it enters the territory of the Male Polissya and expands to 20 km.

On the latitude of Pidluzhzhya-Semyduby villages the Ikva river crosses the Volynian Forest Uplandand near Torgovytsya village and enters the Styr river, which is the right tributary of the Prypyat River and belongs to the Dnieper River Basin.   Total slope of the Ikva river basin is estimated to 0.69 m/km.

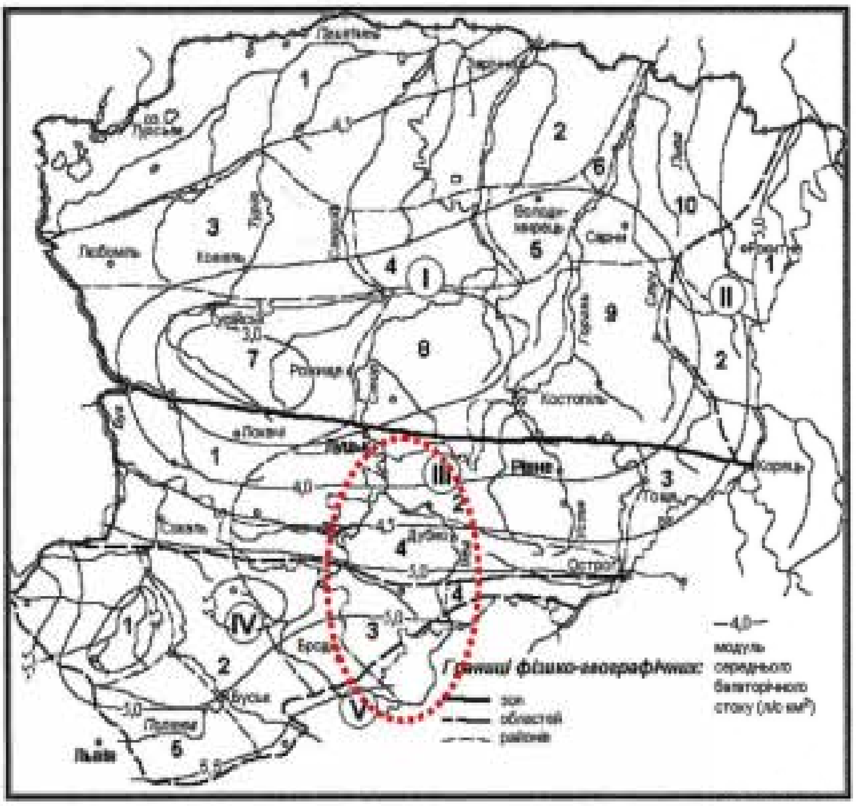

Figure 6. Specific runoff (l/km^2 sek) from the area in Western Polissya where Ikva River is situated.

The specific runoff in the area is approximately 5 l / km^2 sek, see **Figure 6**. If that figure is multiplied by the size of the catchment of 2250 km^2, it gives an average water flow of approximately 11,3 m^3/sek at the confluence with Styr River.

The average water quality of Ikva River is given in **Table 1**.

Table 1. Average concentration of some water quality parameters in Ikva River

Parameter	Calculated base , mg/l
BOD	5,8
Suspended substances	5,2
Sulphates	42
Chlorides	25
Oil substances	0
Fe	0,21
Nitrogen ammonium	0,5
Nitrites	0,01
Nitrates	4
Calcium	112
Magnesium	6,08

The water is characterized as calcium rich and rich in chloride and sulphate. The relatively high concentration of biological oxygen demand (BOD), as well as of nitrate, indicate that the river is impacted by human activities (sewage discharges and agricultural runoff). More details on the water quality are given in the appendix.

4.2 Hydro geological conditions

In order to choose the efficient basin-based water resource management scheme, it is necessary to know the peculiar conditions of the active groundwater-exchange zone.

According to the hydro geological classification the Ikva river basin is situated in the central part of the Volynian-Podilian artesian basin. The peculiarity of the groundwater lies in the conditions of their formation and transit in different geological and geomorphologic zones: slopes of the Podilian plateau ending by the Kremenetsk ridge, the Malopolisska valley and the Volynian Forest Upland.

5.2.1. Hydro geological Stratification

While identifying stratified hydro layers, their rock lithology, hydrodynamic characteristics, chemical composition and geofiltration properties of rocks have been taken into account. Within the Ikva river basin there have been demarcated the following aquifers and systems:

- Contemporary swampy sediments;
- Contemporary alluvial and alluvial-diluvial sediments;
- The Upper Quaternary alluvial deposits of the stream terrace;

- The Middle Quaternary glaciofluvial deposits;
- The Neogene formations;
- The Upper Cretaceous deposits of the Turonian stage;
- The Cenomanian Upper Cretaceous deposits;
- The Devonian deposits;
- The Silurian deposits.

The hydro geological map of the Ikva river basin shows the boundaries of the basin, the pattern of the Devonian aquifer system (the bergstrichs indicate the flow-direction of each aquifer defined by the geological index), the Cenomanian aquifer, the aquifer of the Neogene formations and the pattern of the groundwater system that consists of swampy, alluvial and glaciofluvial water-saturated formations. Below follows the summary of hydro geological characteristics of the hydro geological subdivisions.

The aquifer of the contemporary swampy sediments is widely spread within the floodplain and the stream terrace, over fluvioglacial deposits within the Male Polissya and on the isolated elevations of the contemporary relief where sporadic waters wedge in. A water-bearing formation is the peat with veins of sand and sand clay and capacity ranging from 0.5 to 8 m (peat fields at the Tartatska tributary). The depth of the formation of peat waters ranges from 2 m to 3 m and it may be even deeper in the districts containing draining canals. It is worth noting that the Ikva river valley starting from Sananove village situated at the bottom of the Kremenetski Mountains is thoroughly reclaimed with open canal system. Downstream the reclamation works on the Ikva river continue up to Archyshyn village (Mlynivskyi Rayon). Within the basin, in the segments of crossing with the Male Polissya, the wetlands of the fluvio-glacial valley are demarcated.

The cotemporary swampy sediment aquifer is recharged via rainfall infiltration, surface water discharge and inflow of waters from deeper-lying aquifers. With respect to their chemical composition these are mostly calcium hydrogen carbonate waters with the level of dissolved solids amounting to 0.33 — 0.68 g/dm^3, sometimes the waters with the level of dissolved solids exceeding 1 g/dm^3 occur, which is characteristic of the industrially contaminated area.

The aquifer of the cotemporary alluvial and alluvial-diluvial sediments spreads within the Ikva river floodplain, its tributaries, bottoms of small valleys and erosion strips. The water-bearing formations are differently-grained sands with fine sands prevailing and laminated sands with veins of sand clay and loam. The average capacity of the floodplain alluvium is 5.5 m.

The contemporary alluvial sediments are deposited on the rock units of various genetic origins: marine Cretaceous and Neogene and Neo-Pleistocene fluvio-glacial rocks. Absence of impervious, stable local formations results in strong hydraulic interrelation with the deeper-lying water-bearing formations. Water levels of the contemporary alluvium reach 1.5 m during the low-flow period and during flood seasons they rise to the ground surface. Well yields vary from 0.015 to 1.0 l/sec. when the levels drop to 1-3.5 m.

The aquifer is recharged from the inflow of waters from the deeper-lying aquifers. Waters are discharged into the hydraulic networks, wetlands as well as by evaporation from the floodplain surface. With respect to their chemical composition these are mostly fresh waters containing calcium hydrogen carbonate.

The aquifer of the stream terrace Upper Quarternary deposits spreads along the central and northwest part of the Ikva river valley. Water-bearing formations are differently-graded sands, with fine sands prevailing, with veins of sand clay and total capacity of 12 m. They are underlaid by the Upper Cretaceous sediments. The depth of formation is 1.5 - 3.0 m. Well yields vary from 0.2 to 0.5 l/sec. when the levels drop to 2.7-4.0 m. In terms of their chemical composition these are calcium hydro carbonate waters, which are used by local communities for local water supply needs.

The aquifer of the Middle Quaternary aqua glacial sediments spreads within the Male Polissya where it intersects with the Ikva river basin. Water-bearing formations are differently-graded sands, with fine sands prevailing; the average capacity is up to 7 m. There is a strong interrelationship with underlying aquifers. Well yields reach 3.0 l/sec. when the level drops up to 5.0 m. The water is fresh with the level of dissolved solids of 0.5 g/dm^3. The aquifer is recharged from rainfall infiltration and inflows of water from the Turonian stage Upper Cretaceous aquifer. The waters from the Quaternary aquaglacious sediments are widely used by the local communities for private water supply needs.

The aquifer of the Neogene deposits spreads within the southern and south-eastern parts of the Ikva river basin. The areas of the northern slopes of the Podilian Upland prevail including quite limited watershed segments of the Rivne Forest Plateau of the Volynian Forest Upland. There is a strong interrelationship with the impervious Quaternary rocks, creating the aeration zone, and Cretaceous sediments. The aquifer capacity averages from 10-15 m to 50-65 m. The water table has the same level. The capacity of the water-bearing rocks increases from the Ikva river valley up to watersheds.

The aquifer is not continuous as its elevation on the areas of watersheds is regulated by the drainage conditions marked by the presence of the steep-sided and deep erosion valleys and denes. The water-bearing formations are fine sands, limestone and quartz and glauconitic sandstones. Its spread is conditioned by the presence of Neogene clay formations at the bottom. The total capacity of the aquifer ranges from 0.5 to 15.0 m.

A discharge of the aquifer might be observed at the slopes of numerous steep-sided valleys and denes, particularly within the Kremenetsky Mountains, in the form of gravity springs. The aquifer is recharged exclusively by means of the rainfall infiltration while the discharge occurs through the step system and the water flow into the deeper-lying Cretaceous rocks. In terms of their chemical composition the Neogene waters are calcium hydrogen carbonated with the level of dissolved solids amounting to 0.2-0.7 g/dm^3. The presence of polluting ingredients in the water of some segments indicates that the aquifer is not protected from sanitary pollution.

The aquifer of the Turonian stage Upper Cretaceous sediments is generally spread in the Ikva river basin. It is overlapped with the deposits of different origin and the Neogene formation and underlaid by the Devonian and Silurian and partly Cenomanian formations.

Lithologically it is composed of chalky clay and chalk-stone with total capacity of 70 m. Generally, there is a colmatation zone, which creates an impervious layer, in the upper part of the section.
The reservoir properties of the chalky clay and chalk-stone formation are determined by its fractured and karsted condition. The rocks lying at the depth from 30-40 to 60-70 m from the ground surface are the most fractured, the fractures became less frequent on the deeper levels. On the areas close to watersheds the amount of fractures in the chalk sand is insignificant but the chalk sand becomes more fractured within the Ikva river valley. This aquifer in the Ikva river basin is the key source of the drinking quality water supply for the large populated areas. In terms of its chemical composition the water from the chalky clay and chalk sand formation is calcium hydrogen carbonated water containing essential micro components allowing it to be used as the water for medicinal and nutritional purposes.

The aquifer of the Upper Cretaceous Cenomanian sediments is almost generally spread within the Ikva river basin, excluding watershed area of the Rivnenske Forest Plateau in the segment of the Povchanski dislocations, to the west of Dubno. The water-bearing formations are limestone, sandstone and sands with maximum capacity of 10 m. These deposits are overlapped with the chalk sand formations and underlaid by the Silurian and Devonian formations. The Cenomanian aquifer is saturated. Its water level is close to the ground surface and in some cases it is 3-5 m above the ground. This aquifer is recharged by the waters from the deeper-lying Paleozoic aquifers. In terms of their chemical composition these are hydro carbonate waters, sometimes calcium magnesium or calcium carbonate hydro carbonate-sulphate waters with the level of dissolved solids amounting to 0.3-0.5 g/dm^3.

Taking into account the low capacity of the Cenomanian aquifer, it is recommended to use it for the community potable water needs only in combination with upper and lower lying aquifers.
The aquifer of the Devonian deposits is significantly spread within the Ikva river basin. Its below-the-Upper-Cretaceous-formation outbreaks can be observed along the line drawn from the northwest to the southeast presumably through the following communities: Dobratyn (Mlynivskyi Rayon) - Smordva - Velyki Sady - Kamyanytsya - Sudobychi - Smyga - Viliya and farther beyond the territory under survey. The Devonian sediments are dipped at a small angle to the west, where they are deposited at a depth of 70- 90 m. They crop out the ground surface near Povcha village.
Limestone and dolomites make up the water-bearing rocks. There are layers of sandstone and clay stone with rare occurrence of conglomerates. The subsurface waters circulating in the Devonian deposits have the properties of the saturated aquifer. The reservoir properties of the Devonian aquifer are determined by the presence of fractures and pores (3.5 - 9.0 %). The standard yield is 1.0 - 3.5 l/sec. at lower levels of 3.0- 17.0 m.

In terms of their chemical composition these are calcium magnesium, calcium hydro carbonated waters with total dissolved solids of 0.3 - 0.7 g/dm^3. The Devonian aquifer waters are securely protected against industrial contamination and widely used for the community potable water needs.
The aquifer of the Silurian deposits outbreaks below the Cretaceous surface in the eastern part of the Ikva river basin. Dipping to the west, it is overlapped by the Devonian formations and underlaid by the Vendian deposits. The water-bearing rocks are limestone, siltstone and mortar with layers of clay stone.

The aquifer of the subsurface waters circulating in the rocks mentioned above, is saturated. The level of its water in the Ikva river valley is measured at the ground level and at the depth of up to 30 m for the watershed areas. The well yields vary from 0.5 to 4.5 l/sec. at lower levels of 8.5 m. In terms of their chemical composition these are hydro carbonated waters with the level of dissolved solids amounting to 0.4 - 0.6 g/dm. This aquifer might be used for balneological purposes in the segments of seismic dislocations provided, there are water feeding zones. It can not be used separately.

5. Provisional identification of water bodies

5.1 General

According to the WFD a water body should not consist of more than one water type, the whole water body has to have the same status, and be in the same risk category. As these analyses apply to the water body, it is necessary to do a provicional division of the river into water bodies for which the typification, the risk assessment, and the status assessment can be done. In addition, the provicional water bodies should be evaluated with respect to being heavily modified or not, i.e. has undergone extensive physical changes.

When all these analyses are carried out, the final list of water bodies can be given.

5.2 Provicional identification of water bodies

Natural conditions of the region where the Ikva river basin is formed, environmental and economic characteristics and degree of development pressure on water ecosystem define the approaches to selection of the efficient water use scheme and restoration of this aquifer system to stable operation. By its administrative and geomorphologic location the Ikva river basin is situated within the boundaries of three regions: Lviv Oblast, Ternopil Oblast and Rivne Oblast as well as in three geographical zones (the Podolian Upland, Malopolisska Flatland and Volynian Wooded Upland) that should be taken into account while singling out certain types of water bodies.
According to the integrated assessment of the Ikva river sub-basin it is appropriate to single out the following bodies-sectors:

1. Brodivskyi. The source of the Ikva river up to the administrative border with the Ternopil Oblast. This body is 23 km long. Along this part the Ikva river has not formed the main elements characteristic of the river valley (floodplain terrace, etc.) yet and has only the stream bed (channel) and two tributaries near villages Lukashi and Tetelkivtsi.
It is necessary to establish environmental and sanitary control of the water bodies within the Brodivskyi sector. It is also necessary to monitor the conditions of the natural spring-sources of the Ikva River, as well as to ensure regulated disposal of domestic waste, etc. on the local level. To organize purposeful activities aimed at preservation of the Ikva river sources in their natural state.

2. Kremenetskyi. This part of the basin spreads from the border with the Lviv Oblast up to Male Polissya. Formation of the river valley begins on the specified territory. There appear left and right tributaries up to 10 km long.
The main activities, organized on the local level, should be directed at restoration of the natural conditions pertaining to evolvement of the river basin.

3. Malopolisskyi. This part of the basin covers the territory of Male Polissya both in the Ternopil Oblast and in the Rivne Oblast. The river valley and the total Ikva basin expand significantly. The floodplain and the terrace above the floodplain are reclaimed with the open canal system.
The environmental research activities and corresponding recommendations should concern the environmental analysis of subsurface waters (the abundance of mineral waters in Bereg village), balneological waters (a holy springwell in Onyshkivtsi village), pollution of subsurface waters with oil products ("Druzhba" oil pipe-line at Smyga village), etc.

4. Dubnivskyi. The development pressure on water ecosystem is the strongest along this part of the Ikva river basin with various issues on the list.

5. Mlynivskyi. A lot of fish ponds of various type of land ownership are formed in the lowlands of the Ikva river basin. It requires development of the integrated measures in various areas.

5.3 Identification of the water bodies that have undergone significant changes

5.3.1 Transformation in ground waters as a result of industrial impact (drainage and water consumption)

As mentioned above, the whole Ikva river valley from the Kremenetski Mountains up to Archyshyn is reclaimed. Intrusions into the environment usually result in adverse man-induced processes, which are the combination of interrelated and mutually causal hydrogeological and geotechnical processes occurring in geological environment. The mechanism of the man-induced processes is not sufficiently explored and therefore it is very difficult to forecast the development of such processes over time.
We have made an attempt to list the key negative developments, which have their impact on the environment and describe the factors of their impact as a result of reclamation activities.
The drainage systems varying in area from 600 to 2-3 thousand hectares operate in the Ikva river basin.
Levels of subsurface waters, primarily ground waters, within the boundaries of the drainage systems have decreased by 1.5-2 m and in some cases even more for the period of their existence. This has caused draining of the first near-surface aquifers.
Based on the balance studies conducted in the Belarus Polissya the impact of the drainage systems on the adjacent territories has been calculated.
As a result, the data has been collected, which goes to show that a drop in the level of subsurface waters of around 1 m is observed at a distance of 300 m from the drainage system, a drop of around 0.5-0.3 m - at a distance of 2 km and around 0.2-0.1 m - at the distance of 3-7 km.
According to the data provided by the Dubnivske Drainage System Authority the actual decrease of water in the observation wells, which are situated at a distance of 0.6 - 0.8 km from the drainage systems, amounts to 1-2 meters and above subject to water level in canals.
According to our surveys the impact of reclamation systems on the level of ground waters on the adjacent lands becomes apparent during the low-flow period indicating that large areas of agricultural lands are drained artificially.
The decrease in the water level goes together with changes in the chemical composition of groundwater. It appears to be the waters with mixed composition, mainly of chloride and sulphate type with the total dissolved solid content of up to 2 g and above per liter, which is indicative of transformation of natural waters, as long as it is not characteristic of the natural subsurface waters in our physiographic region.
Draining of the water-rich layers leads to development the industrially created aeration zone where severe oxidation processes take place, which are often responsible for the increase of total mineralization, rise in the content of sulphates and chlorides and the increase of organic substances and total hardness and other changes.
Similar intrusions into environmental conditions took place around the cones of depression of the operating water intake facilities intended for centralized water supply, the only difference is that the range of changes and the factors responsible for them differ significantly. For example, if the level of the first near-surface aquifers decreases by 1-2 m, the industrially created aeration zone within the boundaries of the cones of depression is much larger and deeper than those induced by operation of the reclamation systems.
Analysis of the qualitative indicators of the subsurface waters on the territories suffered from the development pressure showed that for 10 m deep wells the average level of the dissolve solids in groundwater amounts to 1.1 g/dm^3 (with the highest values of 2 - 2. 3 g/dm^3). When the depth is 10-20

m, the average level of the dissolved solids amounts to 1 g/dm^3 (the highest value is 1.4 g/dm^3), and at the depth exceeding 20 m it drops to 0.4-0.7 g/dm^3.
In the layers, which are closer to the surface, the content of sulphates and chlorides also rises, while in the deep wells (up to 20 m) the water contains significantly increased amount of organic substances and sometimes lead. The water is usually harder in the layers of up to 10-20 m deep and in the deeper-lying layers the total hardness does not exceed MPC.
Thus, the survey results have confirmed the assumption regarding the intensity of water oxidation in the industrially created aeration zone. The reliable correlation between the water table depth and the nitrate concentration has been established. The nitrates were found in 70 % of wells, and their high concentration, up to 70 mg/dm^3, is characteristic of waters at the depth of 20 m, in deeper waters the content of nitrates drops to 30 mg/dm^3. This pattern of nitrate content means that the nitrates migrate into the aquifer from the surface. A decrease in the water level leads to reduction of formation pressure and intensifies the process of infiltration from the surface soil layer into the water intake layers.
A continuous intake (drainage) of water resulting in drying up of the aquifer leads to loss of a balancing pressure and an increase of the dried rock weight. It gives rise to rock compaction, which is the process of secondary consolidation. These processes occur throughout the whole area, created during development of the cone of depression owning to a decrease of the subsurface water level.
The secondary consolidation of the dried rocks is the most intense in the central part of the cone of depression, where the aquifer level is the lowest.
It is defined that the pressure on each meter of the dried soft rock increases by 0.1 x 105Pa due to increase in its own weight.
The degree of surface deformation due to secondary consolidation of the dried rocks is conditional on both actual load and physical and mechanical properties of the rocks prior to compression.
With the factors destabilizing natural conditions that act simultaneously, it is especially difficult to forecast the development of man-induced processes. For example, when the formation pressure drops, the crossflow of water from the surface soil layer into the deeper-lying layers increases, therefore intensifying the process of suffosion and giving rise to karstification of the carbonate rocks situated in the upper part of the target aquifer. Simultaneously it leads to formation of the "colmatation zone" in the upper part of the aquifer.
Thus, apart from hydrodynamic transformation of subsurface waters and, primarily ground waters, that occurs due to heavy water intake and reclamation works, there are a number of factors, which have a significant influence on the subsurface hydrosphere.
It should be noted including but not limited to a discharge of untreated wastewaters into watercourses, discharge of harmful substances into air and their deposition on the ground, application of mineral fertilizers, use of poisonous chemicals, construction of filter fields, slurry reservoirs and holding ponds, etc.

6. Typology

6.1 Categories of water bodies

The WFD operates with the following categories of water bodies:

Lakes
Rivers
Groundwater
Marine waters
Transitional waters

In Ikva River basin only the three first categories are present. These have to be typified, i.e. the different water bodies have to be designated its correct water type (e.g. a brown humic water type, a clear water type, a calcium rich water type, etc.).

6.2 Typology system

There are many types of water in the nature. There are brownish stained humic waters in contrast to clear waters. There are turbid waters. There are waters rich in calcium and waters poor in calcium, often called hard waters and soft waters. There are shallow lakes and deep lakes. These different water types have different biology and different concentrations of chemical constituents due to differences in natural conditions. As “impact” in WFD is defined as "deviation from natural conditions", it is necessary to designate the water bodies to the right water type. This to be able to assess what concentrations of organisms and chemical compounds can be expected as natural “reference” in the water body. Then the degree of pollution or impact can be assessed as deviation from natural conditions, which in the WFD is called deviation from the “type specific reference conditions”.

Most of the countries (all) use the system A in the WFD as the main basis for defining water body types. The system is shown in **Figure 8**.

First you should decide which ecoregion you are in. On the European level this can be found from the map in Annex 9 of the WFD, see **Figure 7**. The Ikva area belongs to the Ecoregion "Eastern Plains".

1. Iberic-Macaronesian region
2. Pyrenees
3. Italy, Corsica and Malta
4. Alps
5. Dinaric western Balkan
6. Hellenic western Balkan
7. Eastern Balkan
8. Western highlands
9. Central highlands
10. The Carpathians
11. Hungarian lowlands
12. Pontic province
13. Western plains
14. Central plains
15. Baltic province
16. Eastern plains
17. Ireland and Northern Ireland
18. Great Britain
19. Iceland

Figure 7. The different eco-regions in Europe

But it is not enough to decide which Eco-region the river belongs to. The natural background conditions also changes with the type-parameters given in **Figure 8**.

System A Rivers

Fixed typology	Descriptors
Ecoregion	Ecoregions shown on map A in Annex XI
Type	Altitude typology high: >800 m mid-altitude: 200 to 800 m lowland: <200 m Size typology based on catchment area small: 10 to 100 km² medium: >100 to 1 000 km² large: >1 000 to 10 000 km² very large: >10 000 km² Geology calcareous siliceous organic

System A Lakes

Fixed typology	Descriptors
Ecoregion	Ecoregions shown on map A in Annex XI
Type	Altitude typology high: >800 m mid-altitude: 200 to 800 m lowland: <200 m Depth typology based on mean depth <3 m 3 to 15 m >15 m Size typology based on surface area 0,5 to 1 km² 1 to 10 km² 10 to 100 km² >100 km² Geology calcareous siliceous organic

Figure 8. The system A and the parameters that should be used to decide water types. From the WFD.

The elevation is easy to decide. When it comes to geology most countries have used the concentration of Calcium in the water to decide if it is a calcium rich water body or not, and the water color (as mg Pt/l) as an indicator on how rich the water is in organic matter. The siliceous richness is most often the opposite of calcium richness. That means that if the water is very poor in calcium, it belongs to the siliceous water type. The concentration of Si is therefore normally not used as a parameter for typification in most countries.

If you combine all these parameters you will get a large number of water types. However, many of these theoretical combinations does not exist in nature, and many will have a similar reference condition and similar boundary between good and moderate status in biological quality elements, so in practical terms a national typology system consist of approximately 20 river types and about the same number of lake types. The number of ground water types is often much smaller.

Ukraine has not yet developed its own water typology system. Therefore it is not possible to designate the different water body to the different type in a proper way. We therefore adopt a "shadow typology system" here for the demonstration use.

6.2.1 Elevation

The upper reaches of the main stream Ikva River in Lviv Oblast are at an elevation of approximately 350 m and at the confluence with Styr River the elevation is approximately 178 m asl. Between Verba and Bereg Ikva crosses the type boundary (200 m asl) between a lowland river and a mid-altitude river, which means that in this area there should be a boundary between two river water bodies. The shift does not have to be exactly at the 200 m mark, but it should be somewhere in the vicinity. Ikva belongs partly to:

Elevation class 1: Below 200 m = Lowland river
Elevation class 2: Between 200 and 800 m asl = mid-altitude river

6.2.2 Calcium or Siliceous water type

Most countries use the calcium concentration in the water to distinguish between the different geology related water types. There are great differences between the schemes of calcium typology systems in different countries. Scandinavia, for example, is very poor in calcium while most other parts of Europe have high concentration of calcium.

An average system of calcium classes used in North Western Europe has approximately these classes:

Ca-class 1: $x < 4$ mg Ca/l = calcium poor
Ca-class 2: $4 \leq x < 20$ mg Ca/l = medium calcium rich
Ca-class 3: $x \geq 20$ mg Ca/l = calcium rich

If we assume that this is a suitable system for Ukraine, the Ikva River with average calcium concentration of 112 mg Ca/l (i.e. converted from the monitoring results of 5,6 mg ekv/l) belongs to calcium class 3, calcium rich rivers. This will be confirmed by the results of the present monitoring in this project.

6.2.3 Humic matter - organic type

Most countries have adopted a scale of the water color measured as mg Pt/l (compared to the color you get with a Platinum standard) to assess which humic type the river belongs to. In Norway, Sweden, Finland, the Baltic States, and parts of Northern Russia, the humic content of the water can be very high, 100-300 mg Pt/l is not uncommon. With such values the water is dark brown. In many countries the typology system has three color classes, and a color value of 30 mg Pt/l is used as the boundary between humic poor water type and medium humic rich. 90-100 mgPt/l is often used as the boundary towards the humic rich waters.

Humic-class 1: $x < 30$ mg Pt/l = Humic poor
Humic-class 2: $30 \leq x \leq 90$ mg Pt/l = Medium humic rich
Humic-class 3: $x > 90$ mg Pt/l = Humic rich

The monitoring of Ikva does not include color as a parameter. However, organic material as decided by oxidation by $KMnO_4$ is included, and the average concentration is 35 mg $KMnO_4$/l. This corresponds to a color of about 40 mg Pt/l, approximately. It means that Ikva is in the lower part of the medium humic rich water types. It means that the water is regarded as a clear water type (not brown), but at the beginning of becoming visibly, brownish stained.

6.2.4 Overall typification of Ikva River

Although Ukraine has not developed a national typology system after the WFD, the reasoning in the previous sections concludes that the Ikva River is of the following water type:

Lowland to medium altitude, calcium rich, and medium rich in organic material. That means a relatively common water type.

7. Provisional identification of heavily modified water bodies

The Mlyniv Lake is man made created by damming the river and must be regarded as a heavily modified water body (HMWB). In the Dubno area the river is dammed a couple of places, as well as being connected to the comprehensive canal system of the Ikva Drainage System (flood protection, land reclamation), see **Figure 17**. In this area the river must be regarded as HMWB. The upper part of the river in Ternopil oblast is straightened out, see **Figure 9**. But it is not regarded as an ecological problem. The river is regarded by the Ukrainian water experts to be in good ecological status in this region. Therefore it is not regarded as HMWB due to the straightening.

Figure 9. Upper part of Ikva River in Ternopil oblast, just downstream of the border to Lviv. The river is straightened out.

The right tributaries from east are heavily drained and both physically, morphologically, hydrologically as well as chemically impacted by peat extraction, see **Figure 10**. They are regarded as HMWB by the Ukrainian water experts in the team.

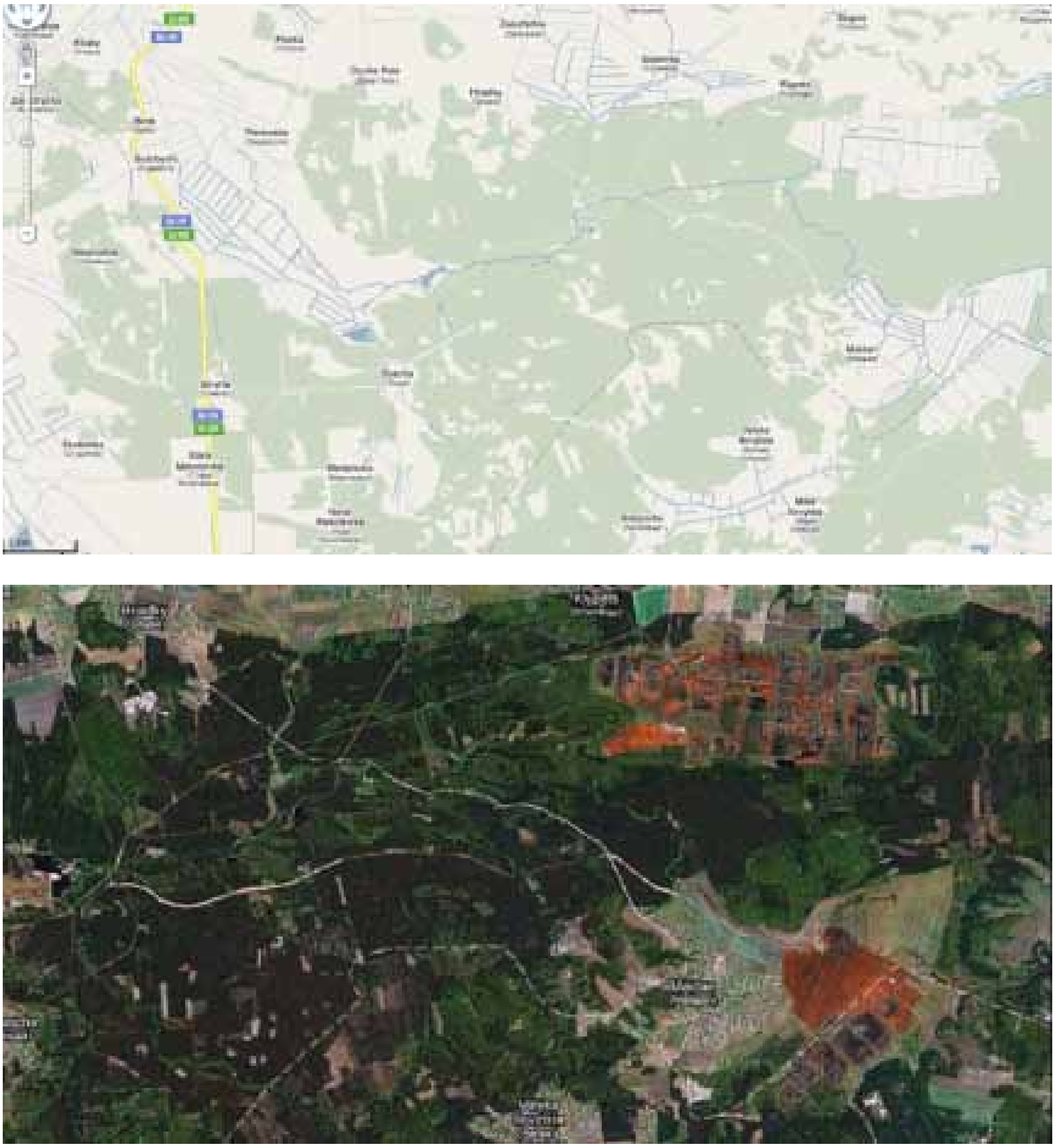

Figure 10. The right tributaries coming in from the east just upstream Dubno are considerably fysically changed due to drainage and peat extraction (brown areas in the aerial photo).

The left tributary coming from west in the same area is fysically modified due to fish ponds and agriculture, **Figure 11**.

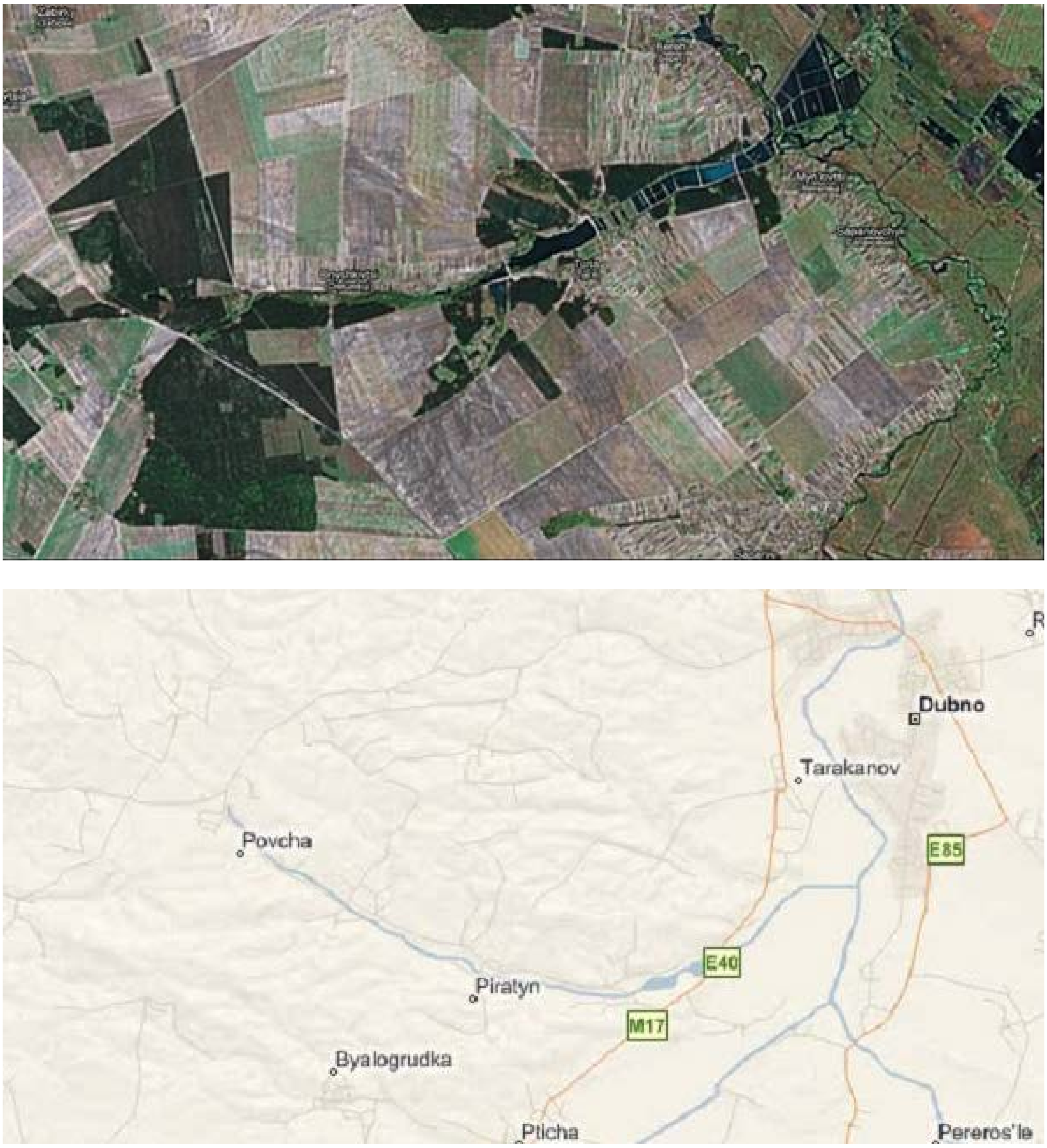

Figure 11.. The left tributary entering the Ikva River just upstream of Dubno is heavily fysically impacted by agricultural erosion and fish pond systems and are regarded as HMWB.

The other parts of Ikva River are provisionally regarded as natural water bodies.

8. Human activity (drivers) and water use

The statistics related to human activity are based on Rayon level, and not on the catchment level. It has not been time to break the information down to the catchment in this demonstration project.

8.1 Population

Table 2 Shows the population in the Dubenskyi and Mlynivskyi Rayons which make up most of the catchment area. There is no statistics that follows exactly the borders of the catchment. The numbers are therefore only approximate.

Table 2. Population in the Dubenskyi and Mlynivskyi rayons which makes up most of the catchment of Ikva River.

City	Actual population size, thousand inh.			Area, thousand km²	Actual population density, thousand inh./ km²
	Total	including			
		urban	rural		
Cities of oblast subordination					
Dubno	38.0	38.0	—	0.027	1.407
Rayons (districts)					
Dubenskyi	46.2	2.7	43.5	1.2	0.039
Mlynivskyi	39.2	8.4	30.8	1.0	0.039
Total:	85.4	11.1	74.3	2.2	0.039

8.2 Agriculture and land use

The distribution of land use in the two largest rayons in the catchment is given in **Figure 12** and **Figure 13** below. It is quite clear that agriculture is very dominating (70-85%), with forest number two (15-25%). The other categories are only constituting minor parts of the catchment. The official statistics confirms the impression you get from the satellite image, see **Figure 16**.

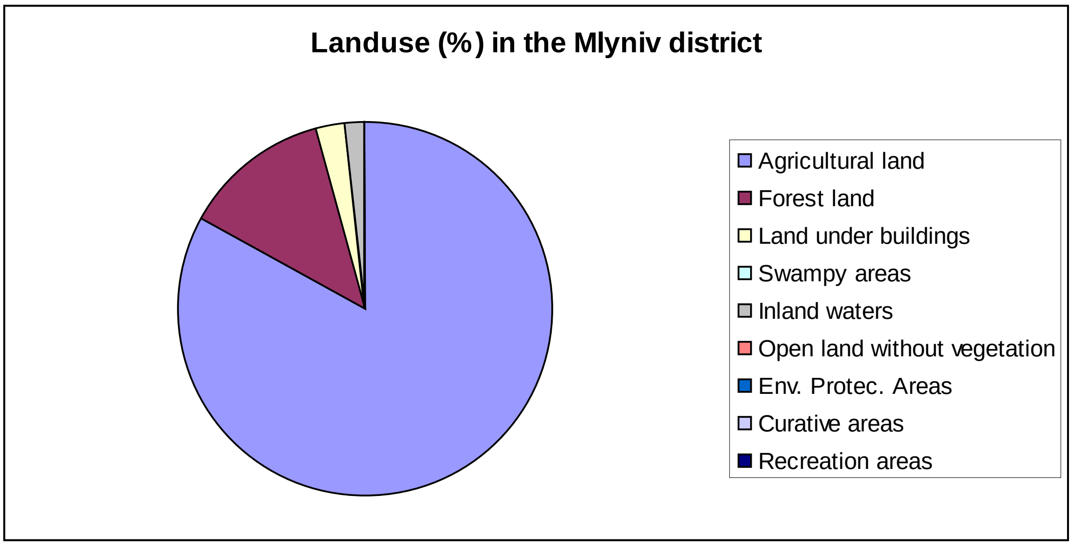

Figure 12. Land use (%) in the Mlyniv district.

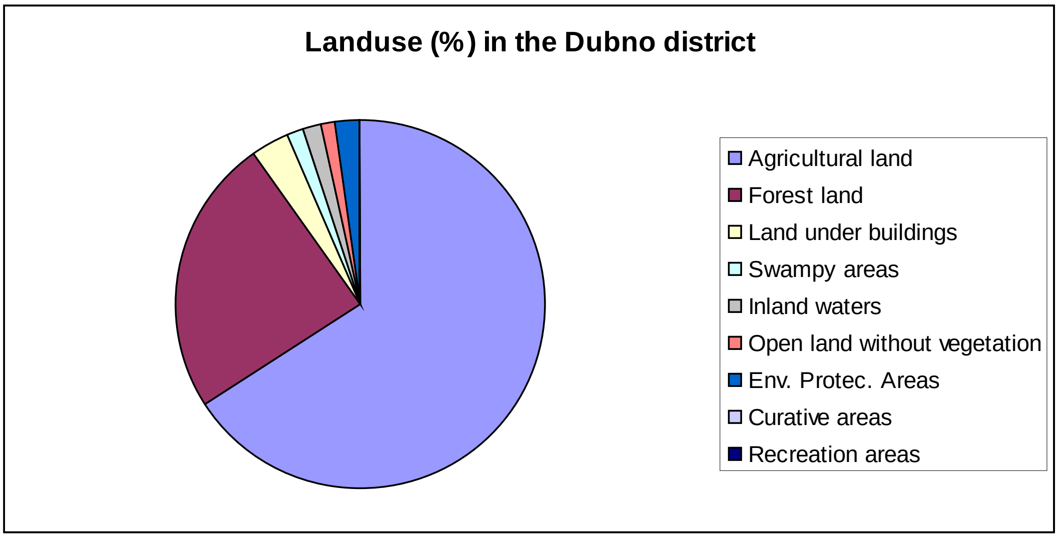

Figure 13. Land use in the Dubno district (%)

8.2.1 Agriculture of Dubnensky district

Agricultural complex

The main aim of the agrarian policy of the district is stabilization and increasing of the amounts of production in agricultural sector through the increase of the effectiveness of farming and creating competition in the agrarian field. In year 2000 the formation of the private agrarian enterprises had ended. The formation of the infrastructure of the agrarian market is still in the process. Based on the 21 collective farms in the process of reforming, 39 new formations were created. Now 96 farm organizations are active.

Main directions of production in the field of vegetation:

*cultivate grain-crops, where the main part take winter crops (wheat) and corn for silage and green forage.
* cultivation of potatoes;
* beets grown;
* seed production.

Main directions of production in the field of animal husbandry:

* livestock farming (milk-meat cattle, pig / swine breeding) ;
* poultry farming.

In the territory of Dubno region within the basin of Ikva river there are three farms divided into five units (**Figure 14**), which are engaged in livestock breading and pig breeding such as:

Village Stovpets:

1. PE “Siagrus” (Pigs – 740 pieces.)

Village Verba*:*

2. PAE “Ukraina” (livestock– 144 pieces., pigs – 121 pieces.)

Village Ploska:

3. VPE named after L.Ukrainky (livestock – 1600 pieces)
4. SE Myrogoshchansky derzhavny ipodrom (livestock – 1000 pieces., pigs – 2400 pieces.)

Village Shepetyn:

5. VPE “Nyva” (livestock – 1000 pieces)

head of livestock in the district:

All categories of farms: lifestock – 19,5 thou.pieces, including cows– 9,7 thou pieces; pigs – 29,3 thou pieces; sheep – 1,5 thou. pieces; poultry – 383,1 thou pieces.

Among the general amount of agricultural products a great part belongs to field vegetation. Among the technical crops, the first place occupies sugar beets.

8.2.2 Agriculture of the Mlyniv district

Agricultural complex

36 agricultural enterprises are active in the district, 53 farms, 4606 households and 11760 other land users which use 58987 he of land. From the total number of agro firms 26 use the more than 100 he of land for their production

As on 01.09.09 agricultural enterprises number 4853 pieces of livestock, including cows in the amount of 1338 pieces. The number of pigs corresponds to 4355 pieces. The amount of poultry corresponds to 317 thou.

On the territory of Mlyniv region within the basin of Ikva river basin there are four such farms (**Figure 15**):

V. Pidgajtci:

6. PAE “Pravda” (Pigs – 2000 pieces., lifestock – 2008 pieces.)

V. Ostrozhec*c:*

7. LLC JV “Idna” (Poultry – 150 thou pieces. Pigs – 2400 pieces.)

V. Vijnytsia:

8. PAE “Nove zhyttia” (Pigs – 360 pieces, lifestock– 1500 pieces.)

V. Bokijma:

9. PE “Demetra” (Pigs– 2000 pieces.)

Liquid waste products are temporarily stored at the pus territories and later are used at the agricultural fields as organic fertilizers.

8.2.3 Agriculture of the Kremenecky district of Ternopil region

Ternopil part of the Ikva river basin is located at the territory of the Kremenecky district.

In this district the total area of the agricultural fields is 91,8 thou he. Out of this amount for the agricultural purpose– 66,1 thou he, including ploughed fields – 51,0 thou he; hayfields, depastures - 4,2 thou he.

The lands of the region (mostly cespitose, black soils) are used for growing agricultural crops.

Animal husbandry mostly is concentrated in a private sector.

In the basin of Ikva river there are no big lifestock farms. In small existing farms (“Gomin”, “Ranok”, “Gart”, “Kryzhi”), which are engaged in milk-meat lifestock breading, the number of pieces are calculated in dozens.

Small amount of liquid waste which are created from the activities of above mentioned farms are distributed in the private agricultural lands.

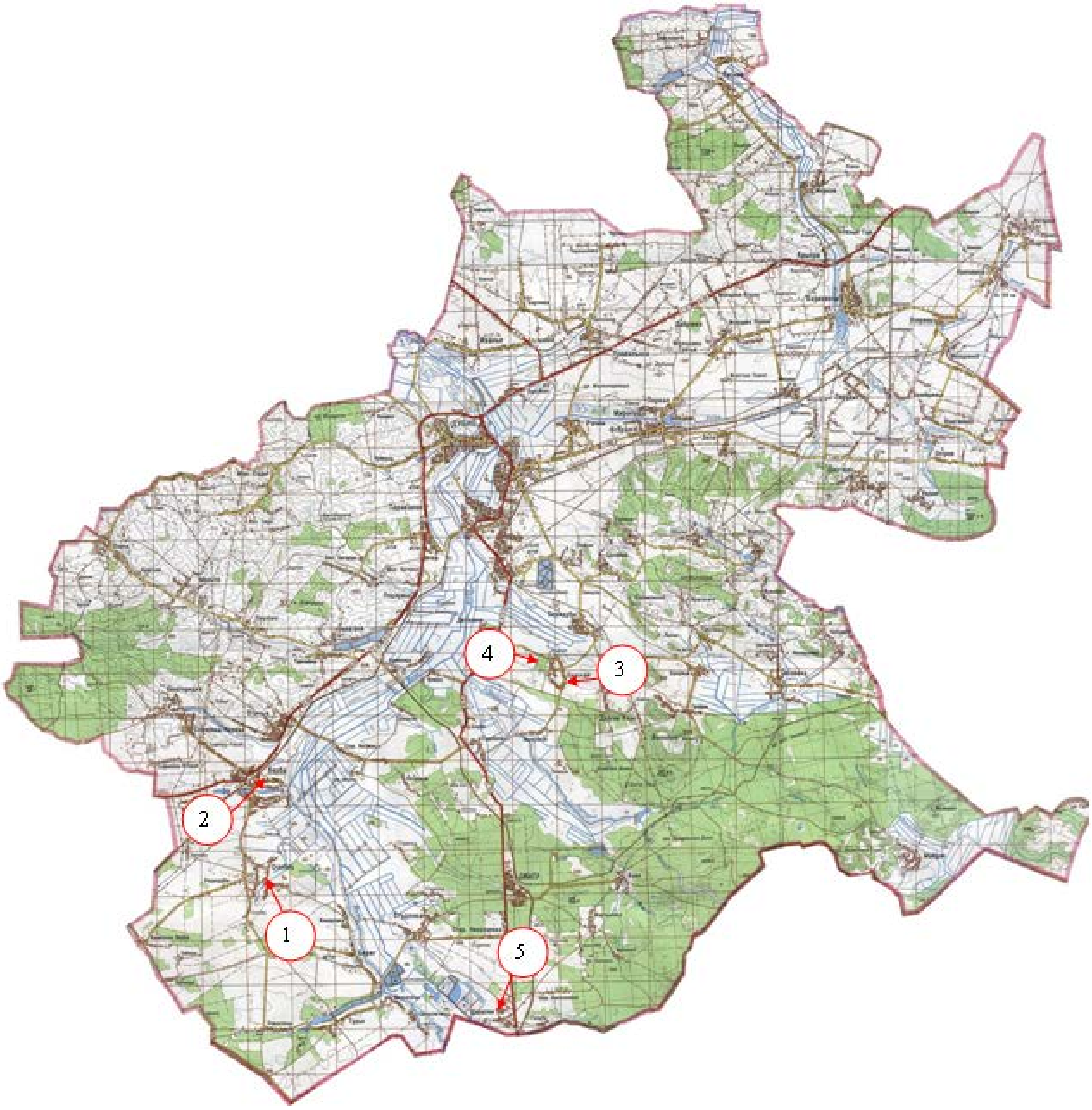

Figure 14. Livestock farms in the Dubnensky District

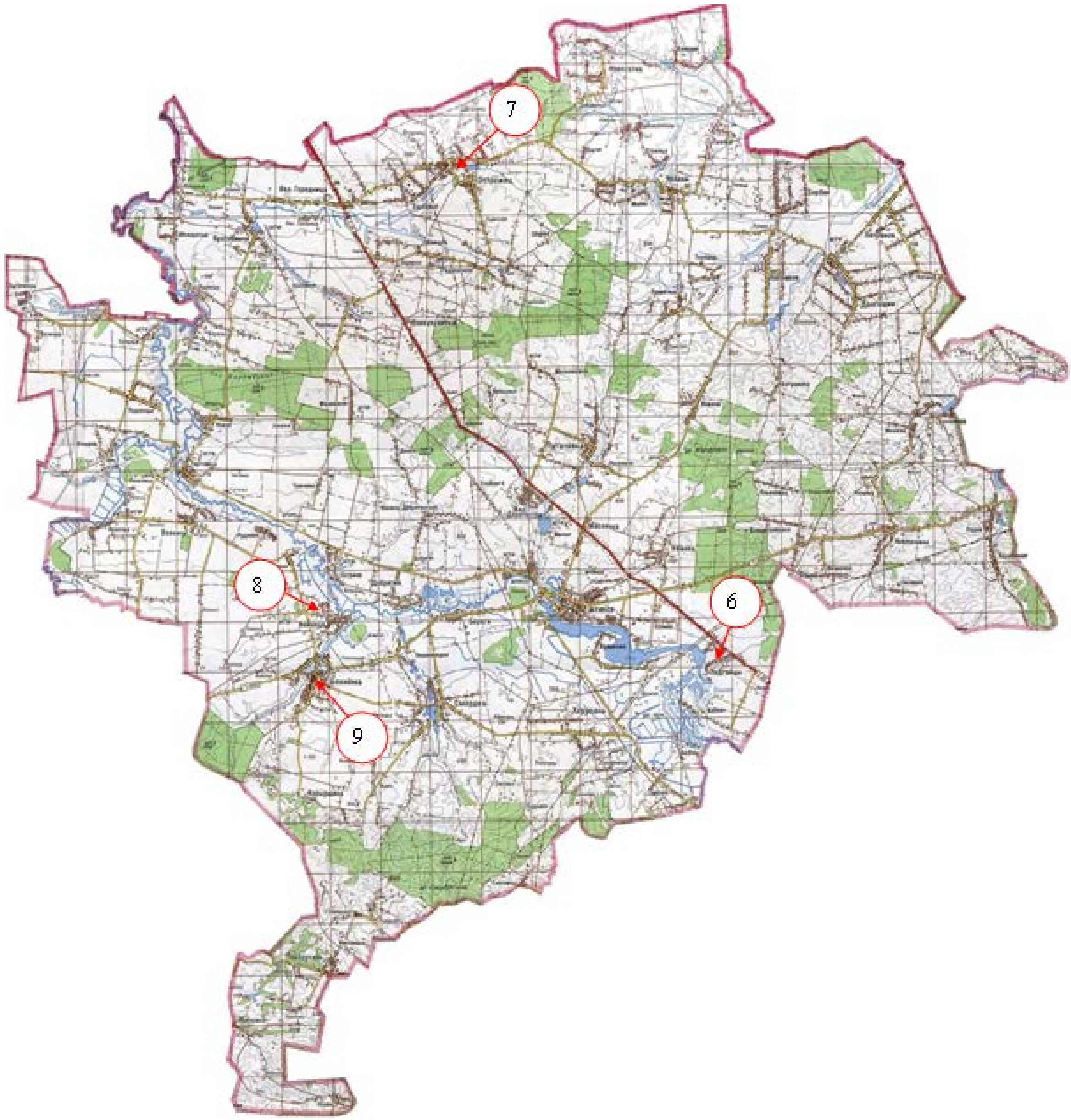

Figure 15. Livestock farms in the Mlyniv district

Figure 16. The Catchment of Ikva River (Google earth). The catchment borders are only approximately drawn. The picture gives an impression of the extent of the farmland in the catchment, but the resolution is not good enough to do any exact land use analysis.

8.2.4 The Ikva drainage drainage system

The Ikva Draining System (**Figure 17** , **Table 3**) is situated on the border of the Dubenskyi Rayon of the Rivne Oblast (on the border between the Rivne and Ternopil Oblast) in the floodplain of the Ikva river. The open canal network in combination with the tile drainage was used for drainage.

Table 3. Technical data of the Ikva drainage system

Name of the drainage system	Net area, hectares	Agricultural land area, hectares	Tile drainage area, hectares	Main soils
the Ikva	9003	5125	5136	Peat-bog, swampy meadow

Natural zoning:

The Ikva Drainage System	Lower part	The Volynian-Podolian Upland	Povchanska-Regular-Undulating Upland Mizotska Undulating Upland
	Upper Part	The Volynian-Podolian Upland	Kremenetsko-Dubenska High Outwash Plain

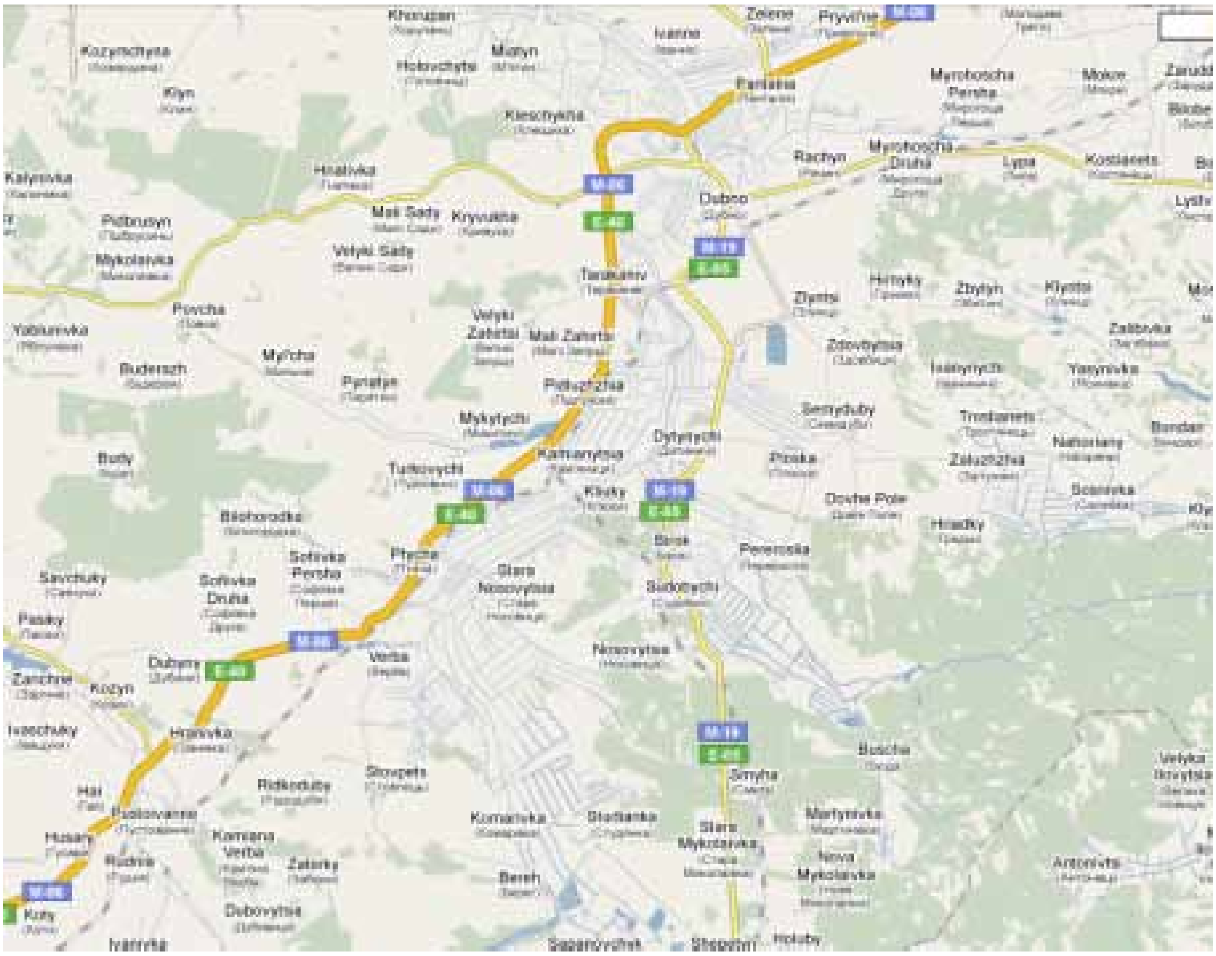

Figure 17. From the Ikva Drainage System

The process of watering (irrigation) is complicated due to lack of water in the Ikva and absence of water reservoirs. The system comprises five polder areas. In terms of geological structure the upper formation of the Ikva valley area consists of Quaternary and Upper Cretaceous Sediments. The

Upper Cretaceous sediments are deposited at the depth of 9-13 m and composed of malmstone and chalkstone. The Quaternary rock formation includes fluvioglacial, alluvial and contemporary swampy sediments. Fluvioglacial sediments are deposited at the bottom of the Quaternary formation in the southern part of the mass and consist of fine quartz sands. Deluvo-aelian sediments are deposited at the Ikva river banks and are represented by the loess sand and loam. Their capacity totals 10-15 m. Alluvial deposits are represented mainly by the fine sand with capacity up to 19 m. Swampy sediments are dark-brown peat, carex peat of different degrees of decay. The peat capacity ranges from 2 to 3 m, while sometimes reaches 6.4 m. In terms of hydrogeology the drained area is situated within the boundaries of the Volynian-Podolian artesian basin. The aquifers are situated in the Quaternary and Upper Cretaceous deposits. The Quaternary aquifer is an integrated aquifer with capacity of 17-19 m. The Upper Cretaceous aquifer is situated in the malmstone and chalkstone formation.

For the purpose of hydrologic condition, water balance, hydrometrical, hydrochemical and soil study as well as monitoring of the drainage system operational conditions the Rivne Hydrogeological and Reclamation Work Company has located 11 cross-sections, including 2 reference cross-sections. The drained lands are used for planting of annual and perennial grasses, grain crops, vegetables as well as fodder crops. Some lands are used as natural pastures.

The peat-bog soils of low floodplain peatlands of forest steppes in the southwest of Ukraine tend to change their salt balance indicators in time and it means that they are going through the stage of evolution (succession). It can be explained by progressive intensification of aerobic processes because of a sharp drop in the level of groundwater and a change in water conditions as a result of draining.
A rise in the content of water-soluble salts owing to sodium salt, chlorides, sulphates may lead to salting of these soils and to partial or total loss of productivity. The salting is probably enhanced by the water cycle focused on infiltration and discharge given the carbonate mineral bottom and the mineralized Upper Cretaceous water.
Despite the signs of future stabilization (hyperbolic curves), the forecast based of the regression analysis allows to assert that provided the groundwater level remains low (›1 м), it is in 2004 that a part of the drained peat-bog soils will be strongly affected by salt in the form of chloride and slightly salt-affected by sulphates and dry residue. It is fair to say that according to the agro-ecological typology the generic characteristics of the peat-bog (alkalitrophic peats) soils are changing from calcereous to sodic-alkaline. The measures for prevention (or slowing down) of this process require development in the course of further research.

On the waterlogged peat soils the swamp meadow grass (Poa palustris L) and chickwood (Stellaria alsina L) prevail (**Figure 18**).

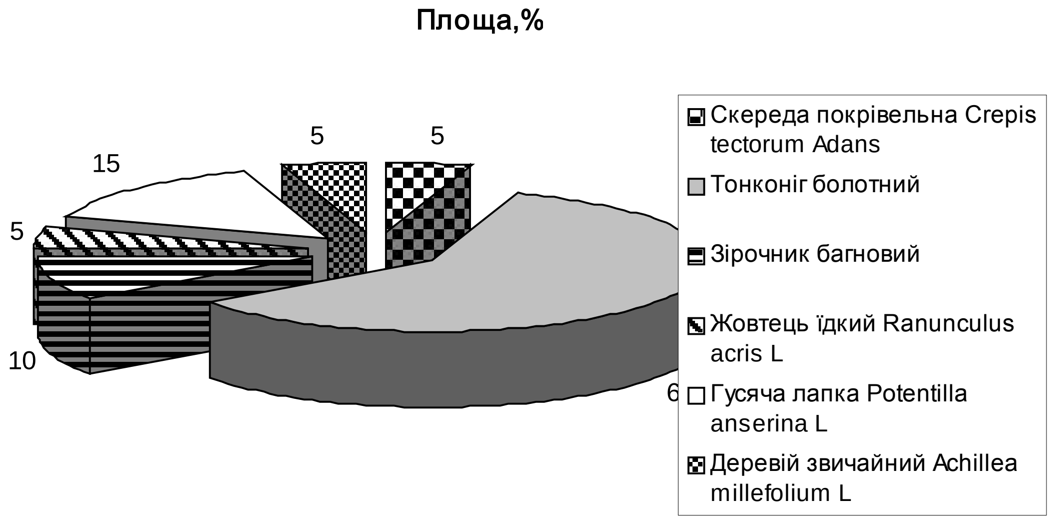

Figure 18. Plant Community Composition at the Reference Station #12 of the Ikva Drainage System Peat-bog soil, GWL=0.5 m.

The main group of grass formations comprises sedge and crop families. It is observed that some typical hygrophytes and hydrophytes are replaced by hydromezophytes and mezophytes that are proved by the absence among the dominant species such plants as achorus (*Acorus calamus* L), common sundew (*Drosera rotundifolia* L), valeriana (*Valeriana officinalis* L.). The dominant species are typical mezophytes such as common couch-grass (*Elytrigia repens* (L) Nevski), meadow foxtail (*Alopecurus prutensis* L,) perennial ryegrass (*Lolium perennel* L), orchardgrass (*Dactylis glomerata* L.)

An increase in plant biomass and yield can be ensured by 100 % projective cover during active growth that can be achieved by creation of optimum soil conditions by means of regulation of watering in the area, agrotechnical measures, selection of appropriate and optimum plant community composition.

8.3 Industry

There is one sugar factory in the catchment, called Niva LLP. This factory discharges 112 000 m^3 effluent water per year. No data on the content of this effluent water is given. Normally effluents from suger beat factories contain a lot of BOD, as well as nutrients. No other industry is mentioned in the primary data given.

8.4 Hydropower

There is only one hydropower plant in Ikva River, in Mlyniv, utilizing the head created by Mlyniv dam and utilizing the Mlyniv lake as a reservoir. This power station regulates the water level in Mlyniv Lake 1-2 meters.

8.5 Economic analysis of water use

Natural water resources in the Ikva River basin is used for the following categories:

Drinking water
Process water for industry

Water supply to aquaculture (fish ponds)
Hydropower production
Recipient for municipal wastewater
Recipient for industrial wastewater
Irrigation of agricultural land in dry periods
Commercial fishing
Recreational fishing
Bathing
Boating and transportation

It has not been performed any economic analysis of these different uses.

Drinking water is mainly taken from the ground water which is evenly distributed all over the catchment. In most areas the quality of the groundwater is good, but in some areas it is polluted by nitrates and pesticides from agriculture. The heavily drainage due to the land reclamation, has lead to up to 2 meters lowering of the ground water level, as well as to oxidation processes in the soils and to a slightly increased salt concentration in the deeper ground water.

9. Pressures and impacts

From the point of view of hydrology the Rivne region is situated in the area of three artesian subsurface water basins: Volynian and Podilian, Prypyat and Ukrainian fissure water basin. The projected resources of the subsurface waters of the region are estimated at 5579.9 thousand m^3/day. The reserves of subsurface water at the developed pools amount to 493.062 thousand m^3/day.
The rivers in the region belong to the Prypyat river basin and are recharged mainly from melted waters and partly from groundwater and rainfalls. The largest rivers are the Goryn, the Styr and the Goryn's tributary - the Sluch. The main direction of flow is from south to north, which is due to the general lowering of the area from the Volynian Forest Plateau to the Polissya Lowland.
The greatest lakes are the Nobel Lake (4.7 km^2) and the Bile Lake (4.5 km^2). The Nobel Lake is situated in the Prypyat floodplain and its maximum depth is 11.3 m. There are a lot of lakes in the floodplains of the Goryn, Styr and Veselukha.

The quality of water in water bodies and water courses is significantly affected by the wastewaters disposed by industrial and utility enterprises and the substances washed off the urban territories or agricultural lands, which pollute water bodies.
In 2008 9.41 million m^3 of the untreated or insufficiently treated wastewaters was discharged into the Ikva River from the wastewater treatment facilities. The reason for the inadequate performance of treatment facilities is their out-worn and out-of-date equipment, delayed maintenance and overhauls. The economic regulations of the water resource protection is inefficient including the issues regarding the adequate assessment of damages to waters resources caused by violations of the environmental protection legislation by the economic entities.

With respect to anthropogenic pollution the subsurface waters are much better protected than the surface water resources. Due to lesser anthropogenic pollution the subsurface potable water is regarded among the most important sources of the clean potable water supplied for community needs. Today the artesian waters, which are used for the centralized water supply, basically comply with the sanitary requirements for potable water. However, the groundwater, first from the surface, is significantly transformed and show adverse qualitative changes in their chemical composition. The groundwater pollution is related to irregular storing of toxic chemicals, garbage dumps, and violation of agricultural standards for use of mineral fertilizers.
The potential groundwater pollution sources are the abandoned well bores or well bores that are out of service and require sanitary and engineering blocking, well bores without structured zones of sanitary conditions, especially, when they are in the close vicinity of the pollution sources and do not have a permanent seal.

As a result of the large-scale reclamation works, chemicalization of agriculture, floodplain devastation, and land drainage, industrial and urban development the Ikva river basin has changed significantly: the landscapes of the basin have become less stable, the ecosystems have lost their balance, and the quality of the surface water is worsening.
For the purpose of rehabilitation of the small rivers it is necessary to survey grid station their water protection zones and riversides with subsequent planting of meadows and forests and river banks cleaning.

10. Status based on data from the ongoing national monitoring

The Ikva River is one of many small-size rivers in Ukraine where large discharges of polluted wastewaters are registered. These discharges exceed 1 mln m^3/year and total 91% of all wastewaters. To monitor the quality of water, water samples are taken to identify the impact of wastewater discharges. In this case of the Ikva River the observations were made and the samples were taken at six check stations (**Table 4**).

Table 4. Monitoring stations in Ikva River

№ check station	Location of the monitoring station	Distance from the confluence, km	Rationale for the hydrochemical research
1	the Ikva river - Sapanivchyk village, within the boundaries of the village, on the border with the Ternopil region	80.5	The monitoring station adjacent to the Ternopil region
2	the Ikva rive - Dubno, 4 km above the city, above Dytynyachi village, 0.2 km below the entry point of the Tartatska river	50.0	Baseline station for Dubno
3	the Ikva river - Ivanne village, 3.2 km below the wastewater discharge point from the water treatment facilities of the Dubenska part of Rivneoblvodo-Canal Company.	39.6	Impact of industrial wastewaters in Dubno
4	the Ikva river - Mlyniv urban-type village, below the village, 0.5 km above the wastewater discharge point of the VUKG (Utility Services Department) water treatment facilities	22.0	The baseline monitoring station for Mlyniv urban-type village
5	the Ikva river - Mlyniv urban-type village, above the village, 0.5 km below the wastewater discharge point of the VUKG (Utility Services Department) water treatment facilities	21.0	Impact of the industrial wastewaters of Mlyniv urban-type village
6	the Ikva river - Torgovytsya village, within the boundaries of the village, 1.5 km above the confluence	1.5	The monitoring station at the confluence

For the purpose of the Ikva water quality study the method for environment assessment by surface water quality categories has been used. This method provides the basis for development of monitoring programs, data analysis, description of surface waters and estuaries in Ukraine in view of environment protection and collection of information about the condition of water bodies. This method applies to all surface waters and estuaries of Ukraine. This method, which is based on the uniform environmental criteria, allows to compare the quality of water in the separate segments of the water bodies, in the water bodies of the different regions and of the country in general.
The general requirements specified in this method provide the basis for determination of trends related to changes in surface water quality over time and space, assessment of changes in water resource

reserves, resolution of economic and social issues with regard to environment protection and public awareness.
Environment assessment of water quality provides information about the water as a component of the water ecosystem, water life environment and essential part of the human natural environment.
The description of the Ikva water quality is provided on the basis of the Environment Classification of Quality of Surface Water and Estuaries of Ukraine. This classification includes a wide range of hydro physical, hydro chemical, hydro biological, bacteriological and other indicators reflecting characteristics of abiotic and biotic components of water ecosystems. The following procedure was used for the water quality environmental assessment:

- Collection of samples and acquisition of data for analytical control;
- Definition of categories of water quality;
- Determination of block indices;
- Provision of integrated environment assessment.

The results obtained by the laboratory of the analytical control division of the State Department of Environment and Resources Management are taken as the key input data for environment assessment of the Ikva water quality. These water quality data are grouped over time and space in a certain, distinct order: separately for different monitoring stations for certain segments of the river as a whole for the certain period of time (month, season, year, several years in a row, etc.)
According to the Environmental Classification the input data on water quality are grouped into three blocks. Blocked per each available water quality indicator, the basic data are appropriately processed: arithmetic mean values and minimum, average and maximum (the worst) values are calculated. Taken together, these values describe variation of values of each water quality indicator under natural conditions of sampling and monitoring result analysis (**Table 5**).

Table 5. Water Quality Indikator Values for the whole Ikva River in 2001-2006

Years / Indicators	2001		2002		2003		2004		2005		2006	
	average	max	average	max	average	max	average	max	average	max	average	max
Chlorides	19.4		15	16.4	10.0	12.0	16.0	16.7	16.0	16.5	17.4	19.3
Sulphates	38.3		37.5	50.2	32.3	40.1	29.1	33.1	27.8	32.6	46.8	58.0
Total dissolved solids	514		543	581	526	607	574	579	510	538	473	503
pH	7.84		7.82	8.03	8.10	8.17	8.16	8.26	7.97	8.21	7.52	7.82
Suspended substances	11.5		11.9	14.3	19.8	23.5	8.7	11.7	7.20	7.80	7.53	8.70
Saline Ammonium	0.34		0.23	0.34	0.36	0.40	0.38	0.48	0.28	0.32	0.25	0.36
Nitrate Nitrogen	0.56		0.46	0.60	0.69	0.98	1.13	1.66	1.41	2.20	1.65	2.02
Nitrite Nitrogen	0.006		0.013	0.019	0.012	0.016	0.035	0.048	0.019	0.025	0.04	0.06
Phosphate Phosphor	0.466		0.037	0.052	0.068	0.10	0.042	0.056	0.043	0.050	0.04	0.07
Chemical oxygen demand (COD)	29.3		33.4	46.1	34.8	40.9	24.5	26.7	27.8	29.6	32.5	36.7
5-day biological oxygen demand	2.9		3.5	4.8	4.3	5.2	3.4	4.1	3.5	4.1	2.9	3.5
Dissolved oxygen	9		10.0	11.3	10.1	11.5	9.9	11.8	9.56	10.8	8.78	9.43
Calcium	4.6		3.5	4.7	4.0	4.6	4.2	4.5	5.1	5.6	4.7	4.9
Magnesium	1.5		1.4	1.7	1.7	2.1	1.5	2.1	1.5	1.8	1.52	1.9
Iron			0.17	0.19	0.22	0.25	0.28	0.30	0.23	0.25	0.20	0.27
Copper			0.039	0.045	0.025	0.034	0.012	0.024	0.036	0.039	0.008	0.012
Zinc					0.016	0.019	0.033	0.033	0.037	0.044	0.024	0.032
Manganese			0.040	0.047	0.052	0.084	0.049	0.054	0.040	0.046	0.026	0.036

Note: Chrome and nickel are not defined for any samples and all their values (min, aver, max) fall into I category.

Mathematical statistics methods were used for grouping, processing and use of the input data.

10.1 Determination of cumulative values for water quality indicators

At the next stage of the environmental assessment individual indicators are used to define the water quality categories. At this stage the average mean (average), minimum and the worst values for each indicator were compared with the corresponding water quality criteria. Based on this comparison of the average, minimum and the worst values for each indicator, we have defined the water quality criteria by the average, minimum and the worst values of the indicators.
Further, we processed the obtained values for the categories and received the category values for the whole river (**Table 6**).

The third stage presumed generalization of the water quality assessments per each indicator and determination of cumulative values for the categories. The generalization of values meant calculation of the average, minimum and the worst values for three block indices, namely: for the index of

pollution with salt composition components (I1), for the tropho-saprobiological (environment and sanitary) index (I2), for the index of specific toxic and radiation indicators (I3).
At the third stage of the environment assessments we have determined the values of the block indices (Table 5.1-5.6). The stage of determination of the block values expressed in the water quality categories is very important as the block values must properly reflect the natural or standard conditions of the water body. This stage is based on the results of the preceding stages where the water quality categories are determined for individual indicators. According to the results the group of indicators with the values of the water quality categories reflecting the most favorable or standard condition of the water body is determined.

Table 6. characteristics of the water quality in the whole Ikva River by categories (2001-2006)

Years / Indicators	2001			2002			2003			2004			2005			2006		
	min	average	max	min	average	max	min	average	max	min	average	max	min	average	max	min	average	max
Chlorides		1.3		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.5
Sulphates		1		1	1	1.5	1	1	1.2	1	1	1	1	1	1	1	1.3	1.8
Total dissolved solids		1.7		1.8	1.8	2	1	1.8	2	1.7	2	2	1.7	1.7	1.7	1	1	1.5
pH		2.5		2	2.2	2.8	3.5	3.8	4	3	3.5	3.8	1.8	2.3	3.5	2	2	2.2
Suspended substances		2.7		2.2	2.7	3	2.7	3.5	4	1.7	2.2	2.7	2	2	2	1.8	2	2
Saline Ammonium		3		2	2.5	3.2	3.2	3.2	3.2	3.2	3.2	3.2	2.5	3	3.2	2.2	3	3.8
Nitrate Nitrogen		4		2.3	3	4	3.2	4.2	4.7	3.5	5.3	6	2.7	6.2	6.5	2.5	4.2	4.8
Nitrite Nitrogen		2.3		2.8	3.3	3.8	2.5	3.2	4	4	5.3	5.3	3.5	4.7	5	5	5	5.7
Phosphate Phosphor		6.3		1.8	2.7	3.5	2.7	3.8	4.3	2.2	2.7	3.2	2.7	2.8	3.2	1.7	3	3.8
Chemical oxygen demand (COD)		4.3		3.2	4.7	5.3	4.2	4.7	5	3.5	3.5	3.7	3.7	4.2	4.2	4.2	4.5	5
5-day biological oxygen demand		4		3.8	4.2	4.8	4.5	4.8	5	4	4.3	4.5	3.8	4.2	4.3	3.8	4	4.2
Dissolved oxygen		1		1.5	1	1	1.5	1	1	2	1.3	1	1.8	1	1	2	1.5	1.5
Iron				3.5	3.5	3.5	4	4	4	4.2	4.2	4.2	4	4	4	4	4	4
Copper				5.5	5.7	6.2	4.8	5.5	5.8	1	3	3.2	4.7	5.2	5.2	3.5	4.3	4.5
Zinc							2.3	2.7	3	2.8	2.8	2.8	3.5	4	4	2.3	3.2	3.8
Manganese				2.8	3	3.5	2	3.5	4	3.5	3.5	3.8	2.8	3	3.3	2	2.2	2.8
Nickel		1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Chrome		1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

The next stage was to make the integrated assessment of the water quality in the Ikva river as a whole. At this stage the cumulative (environmental) index (Ie) was calculated.
As a result of calculations we obtained the individual values of environmental indices for the average, minimum and the worst values of the categories. The obtained values turned out to be fractions. This fact allowed for differentiating of the water quality assessment and for making it more accurate and flexible.

10.2 Calculation of the water quality environment indices for three blocks of indicators

The environment assessment of water quality in the Ikva River according to the salt composition criteria was made in compliance with the Method and included assessment of water quality using the criteria of the total dissolved solid level and the presence of the salt composition components.
The salt composition block comprises the following indicators: chlorides, sulphates, total dissolved solids.
As the level of the total dissolved solids was not determined, it was calculated by the cation-anion composition of water.
Σ ion, mg/dm³ = [HCO3]+ [CL-]+ [SO42-]+ [Ca2+]+ [Mg2+]+ [Na++K+]

Alkalinity of the water samples was measured in mg-eq./dm^3. For the purpose of calculations the values of the alkalinity indicator were translated into mg/dm^3 .
Hydro carbonates were calculated as follows:
HCO3-, mg/dm3= (alkalinity indicator value)×61.02.
The units of measurements of the cation-anion composition values were conversed as follows:

- Ca2+ (mg/dm3) = Ca2×20.04 (mg-eq./dm3);
- Mg2+ (mg/dm3) = Mg2+×12.16 (mg-eq./dm3);
- K+Na (mg-eg./dm3)= [HCO3]+ [CL-]+ [SO42-] - [Ca2+] - [Mg2+].

The values of the salt composition indicators at the different points of monitoring indicate that by its natural characteristics the water in the Ikva river is fresh, hypo- and oligohaline.

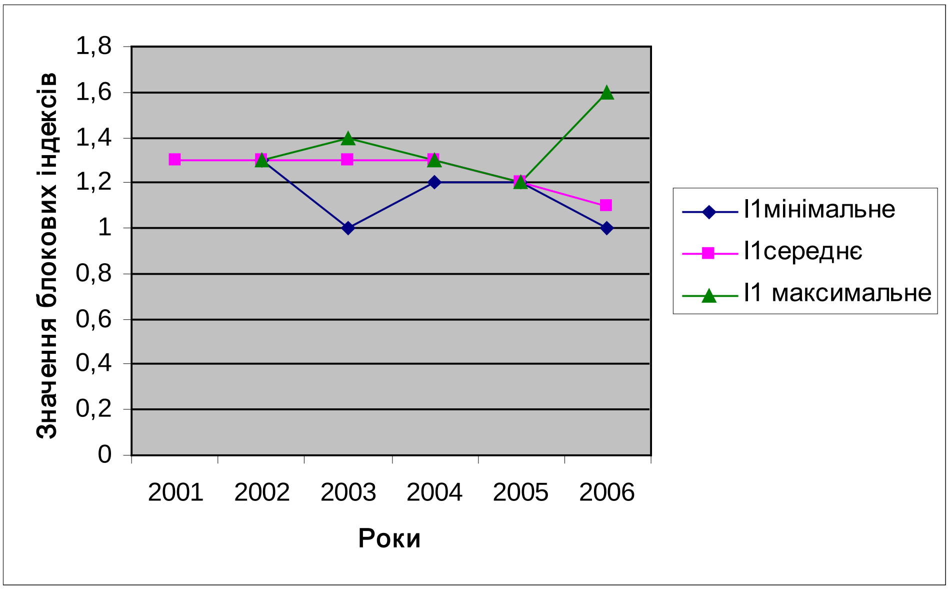

Figure 19. Water Quality Dynamics according to the Salt Block Indices

In the course of research we have established that the insignificant concentrations of chlorides and sulphates are typical for the Ikva river water. Thus, tracing the dynamics of pollution throughout 2001-2006 according to the salt block component indicators, that is to say, the content of chlorides and sulphates, we observed that the quality of water in the Ikva falls within I category according to the average values of indicators and corresponds to quality class I.
The average values of the total dissolved solids ranged within 501-606 mg/dm^3, while the worst values averaged 540-647 mg/dm^3. And it means that the water quality falls into category II and class II, accordingly. The level of the total dissolved solids is under the influence of the physiogeographic conditions of the river basin and the fate of the subsurface waters with increased level of the total dissolved solids. As the Ikva is one of a few rivers in the region, which is recharged mostly from the subsurface waters.
It should be noted that for the average values of indicators the index of pollution by the salt composition components (I1) is within 1.1-1.3, and for the worst values it equals to 1.2-1.6 (**Table 7**).
The tropho-saprobiological block indicators were of overriding importance for determination of the river pollution level.
The tropho-saprobiological block comprises the following indicators: suspended substances, pH, ammoniac nitrogen, nitrite nitrogen, nitrate nitrogen, phosphate phosphor, dissolved oxygen, chemical oxygen demand (COD), biological oxygen demand $(BOD)_5$.
To determine the total amount of organic substances contained in the water such indicator as dichromate value of water
(potassium dichromate – $K_2Cr_2O_7$ – a strong oxidizing agent that may react with all impurities occurring in water and capable of oxidation) is used. The dichromate value of water corresponds to its

chemical oxygen demand (COD), it means that COD is defined as the amount of oxygen required for chemical oxidation of organic and mineral substances contained in one unit of water. The COD value allows to estimate the level of pollution by the substances capable of oxidation, however, it does not provide information about the pollution composition.

Biological and chemical oxygen demands are considered among the most important indicators of the oxygen conditions of water. The biological oxygen demand (BOD) means the amount of oxygen spent for biochemical oxidation of organic substances contained in one unit of water for the specified period of time prior to water and carbon dioxide (oxidation occurs with contribution of decomposers, primarily, aerobic bacteria); this amount of oxygen includes the oxygen that the bacteria-decomposers require for conversion of ammonia and nitrites into nitrates. When there is a sharp increase of organic substances in a water reservoir (first of all, owing to untreated industrial wastewaters), the number of aerobic bacteria dramatically increases. The bacteria consume a lot of oxygen dissolved in the water and may significantly reduce its content that leads to the growth of a population of the anaerobic bacteria and to eutrophication of the water environment. In Ukraine the BOD is measured for five days (BOD_5) and for twenty days (BOD_{20}).

The pH value of water indicating the concentration of hydrogen ions is of high importance from the point of view of environment protection. There is a scale of pH values from 0 to 14. When pH = 7, the water solution is neutral, the solution with pH > 7.5 is alkalic, and starting from pH < 6.5 it is acid. For the most of water ecosystem inhabitants the optimum pH value must not significantly deviate towards alkalinity or acidity. In natural waters the concentration of hydrogen ions is generally related to the ratio of carbon dioxide to its ions. In water the sources of hydrogen ions may be the humic acids prevailing in acid soils, swamp waters, heavy-metal salt hydrolysis. pH influences the development of water plants and the course of production processes. The water reservoir pH depends on a key factor - the organic substance content (that is whether the water is eutrophic or oligotrophic). The springs of artificial origin, especially, industrial enterprises, have the greatest impact on the pH value.

In the analytical control data the phosphate values are given in the form of $P0_4^{3-}$. Since according to the environment classification of the surface water quality categories and classes are determined by the phosphate phosphor indicator, a new calculation was made using the defined factor:

Mg ($P0_4$3-) = 94.97.

Mr (P) = 30.97; P($P0_4$3-) = 0.326.

0.326 - a factor for conversion of phosphates into phosphor phosphates.

According to the hydrochemical monitoring data the indicators of the nitrogen thriad (ammonia, nitrite and nitrate nitrogen) significantly contribute to pollution. Thus, during the monitoring period (2001 – 2006) the total increase of nitrate nitrogen concentration (from 0.56 to 1.65 mg/dm^3) for average values and (from 0.60 to 2.20 mg/dm^3) for maximum values (Table 3) is observed throughout the river.

As to the nitrite nitrogen, its concentration in the Ikva River significantly contributed to the level of pollution as well. With respect to this indicator especially high concentrations were observed in 2004 - 2006. In total, the maximum values for these indicators fall into categories 5, 6 and even 7, which corresponds to water quality class 4 and 5. These extreme values are the result of substantial anthropogenic pressure.

In general, the increased content of organic substances is characteristic of the Ikva River. The average category values for the COD indicator range from 3.5 to 4.7. Especially high concentrations (72.5 mg/dm^3) for this indicator are observed in 2002 in the segment of Mlyniv urban-type village below the wastewater discharge point of the water treatment facilities of the utility services department. The maximum values of the BOD_5 are also high and fall into categories 4-5. As to the dissolved oxygen, all those years its concentration according to all indicator values corresponds to category I.

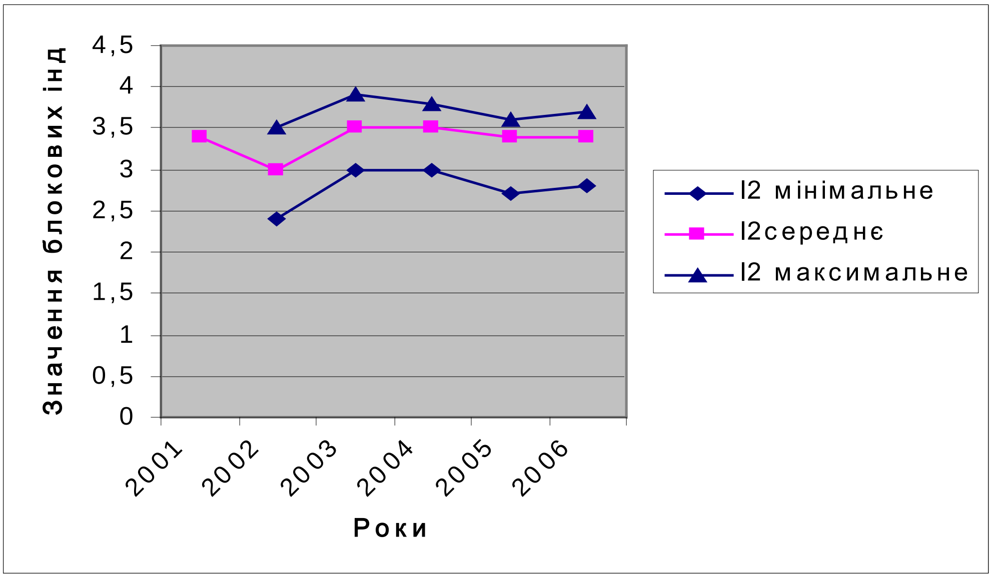

Figure 20.. Water Quality Dynamics according to the Tropho-Saprobiological Block Indices

The river pollution index (I2) for the average values of the indicators range from 3 to 3.5; for the worst values it ranges within categories 3.5-3.9. The water in the river is in transition from II to III class. While analyzing the tropho-saprobiological block dynamic curve, it should be noted that the minimum value of the river pollution index (I2) is observed in 2002 and corresponds to category 3, while the maximum value is observed in 2003 and corresponds to category 3.9, accordingly.
Among the indicators of the water quality environmental classification according to the criteria of the specific toxic substance content, we have studied the following indicators: zinc, copper, manganese, iron, chrome and nickel.
The quantitative parameters of the specific toxic and radiation substance indicators should be close to the baseline values. As a rule, there are very insignificant amounts of chemical elements (copper, nickel, zinc, manganese, common chrome, iron) in the surface water. The Rivne region belongs to those regions where the average content of heavy metals in the water (iron, zinc, copper, manganese) is relatively higher than in other regions. It is due to swamp landscapes, comparatively low water discharge in rivers, zonal distinctions, inflow of chemical elements from the urban territories, human economic activities, etc.

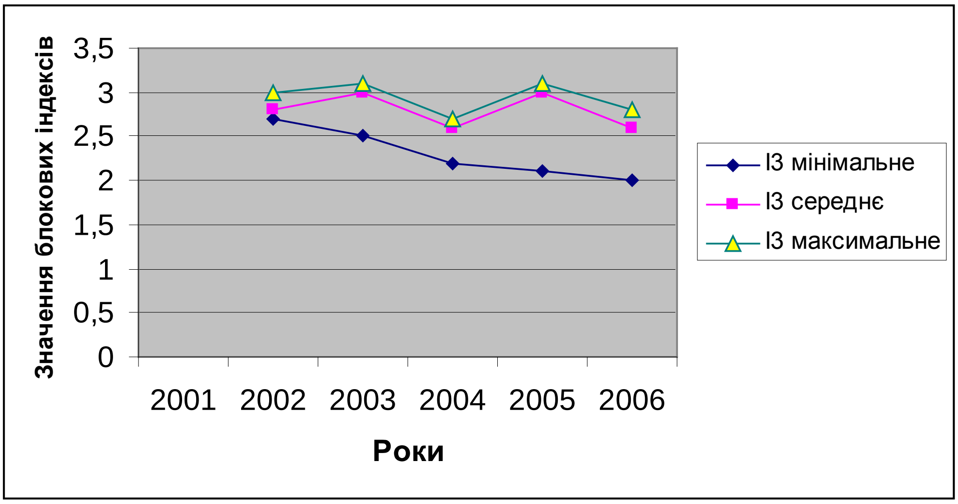

Figure 21.. Water Quality Dynamics according to the Specific Toxic Substance Block

As to the specific toxic pollutants the Ikva River apriopri contains copper, zinc, manganese. In the course of survey, we have established that in 2002 and 2005 the worst values for the content of copper equaled to 0.045 mg/dm³ and 0.039 mg/dm³ that refers to categories 6 and 5 and water quality class IV-III, respectively.
The hydrochemical monitoring data shows that total iron in the Ikva water falls into category 4. Besides, it should be noted that the maximum concentrations of iron in the river were observed in 2004-2006 and amounted to 0.25 – 0.30 mg/dm^3.
Such increased values of this indicator are not the after-effect of the technogenic interference with natural processes occurring in the water ecosystem but the regional geological peculiarity of the Ikva river basin and can be explained by the specific conditions of formation of the river water chemical composition.
As a result of the survey significant concentrations of zinc and manganese were revealed at the monitoring stations. The average indicators for the manganese compounds in the river range from 0.026 to 0.052 mg/dm³ that refer to categories 3 and 4, accordingly. The incidences of significant pollution by zinc compounds were observed as well. Thus, maximum zinc concentrations were observed in 2004-2005 and they reached categories 5 and 6.
Chrome and nickel were not found in all water samples and fall into category I for all values (max, aver., min).
The analysis of values of the indicators from three blocks and calculation of the block indices according to the minimum, average and the worst indicator values allow to calculate the cumulative indices of the Ikva water quality (**Table 7**).

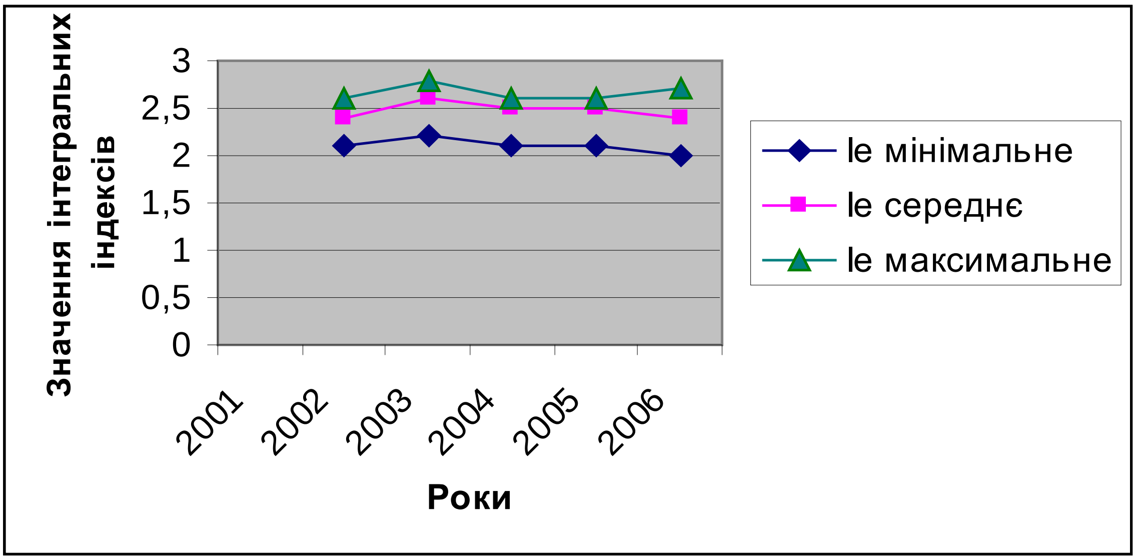

Figure 22.. Water Quality Dynamics by the Cumulative Environmental Indices

Table 7.. values of block and cumulative indices of water quality in the Ikva River

Years	Range of values	Block index values			Value of cumulative index
		I_1	I_2	I_3	I_{Σ}
2001	minimum				
	average	1.3	3.4		
	maximum				
2002	minimum	1.3	2.4	2	1.9
	average	1.3	3	2.2	2.2
	maximum	1.3	3.5	2.5	2.4
2003	minimum	1	3	1.9	2
	average	1.3	3.5	2.4	2.4
	maximum	1.4	3.9	2.6	2.6
2004	minimum	1.2	3	1.7	2
	average	1.3	3.5	2.1	2.3
	maximum	1.3	3.8	2.2	2.4
2005	minimum	1.2	2.7	2.3	2.1
	average	1.2	3.4	2.5	2.4
	maximum	1.2	3.6	2.6	2.5
2006	minimum	1	2.8	1.8	1.8
	average	1.1	3.4	2.1	2
	maximum	1.6	3.7	2.3	2.5

It should be noted that the level of pollution of the Ikva River is determined, primarily, by the values of the block indices I2 and I3, namely, by the values of the tropho-saprobiological indicators and specific toxic substance indicators. Thus, the worst values of the tropho-saprobiological indicators according to the cumulative block index were observed in 2003 and 2004 and equaled to 3.9 and to 3.8, accordingly. Regarding the block of the specific toxic substances, its maximum values ranged from 2.3 to 2.6. At the same time the results of the water quality assessment for the Ikva according to the salt block indicators (I1) do not go beyond the established standards.

In the course of the survey among the input data there were individual extreme values that exceeded the established range of the sample variability. These extreme values of the individual water quality indicators were subjected to the special analysis: identification of natural or anthropogenic reasons, which might cause them. After such analysis the decision was made of either to include or exclude these extreme values of the individual water quality indicators.

10.3 Establishment of the environmental water quality standards for the Ikva River

Apart from individual pollutants, establishment of the environmental standards requires consideration of local and regional peculiarities of the water quality formation and cumulative anthropogenic pressure on the specific water body. Here is the key difference between the environmental surface water quality standards and the water use safety standards with regard to maximum permissible concentrations of individual hazardous substances.

The environmental standards (ES) are established on the basis of the valid and systematic input data by the highly qualified specialists in hydro-ecology. The established ES values are required for acquisition of the persuasive reviews and important decision-making regarding the environment protection activities directed at achievement or preservation of environmental quality of water bodies. The quantitative value of each environment standard corresponds to the most stable value of the water quality indicator, which prevails in the range of variability of its absolute values, can best meet its natural characteristics and is the most desirable in terms of water protection activities. This value of the environmental standards is optimum (ESo). Apart from the optimum values, the permissible values (ESp) of the environmental standards are established, which reflect inevitable deviations from the absolute values of the water quality indicators towards degradation as a result of unstable environmental conditions.

On the basis of the categories calculated for the quality of water in the Ikva the absolute values of the indicators for the optimum and permissible standards are established. The most part of the indicator values are sufficient for normal functioning of the river system. However, some values go beyond the defined range (**Table 8**).

To compare the present river water quality with the established environmental standards the difference between the existing state and the values of the standard water quality indicators was calculated (**Table 9**).

The calculation of difference between the existing and standard values of the Ikva basin water quality indicators showed that:

- the values of the salt block indicators (chlorides and sulphates) are within the optimum and permissible standard limits. But it should be noted that for all years of the survey the values of the total dissolved solids exceeded the actual ESo values and the difference for the whole river amounted to (-23);
- as to the environmental standards for the tropho-saprobiological block, only values of the dissolved oxygen, suspended substances, ammonia nitrogen and BOD_5 indicators comply with the established ESo and ESp. Thus, the difference for the dissolved oxygen values is (+3.4) and (+2.5), and in case of ammonia nitrogen it is (-0.01) and (+0.02), accordingly. The indicators of nitrite and nitrate nitrogen have the paramount importance for the Ikva water quality. However, they exceed ESo and ESp almost 2-2.5 times. Thus, according to the worst values of nitrite nitrogen and nitrate nitrogen for the whole river the difference between the actual condition and the established ESp totals (-0.9) and (0.019), respectively. These are significant deviations of indicators, which normalization requires development and implementation of the water protection activities.
- among the indicators of the specific toxic substance block only the iron values fall into the established environmental standard limits and according to the calculations the difference amounts to (+0.28) and (+0.75), respectively. The values of the copper and manganese indicators do not comply and significantly exceed the established ESo and ESd.

Table 8.. Environmental water quality standards for the Ikva River

№ s/n	Indicators	Established ES for the Ikva river mg/dm³		Surface water quality ES for the Rivne Oblast, mg/dm³	
		optimum	permissible	optimum	permissible
1	Chlorides	15.6	16.2	20	30
2	Sulphates	35.3	42.8	50	75
3	Total dissolved solids	52.3	562	500	750
4	pH	7.9	8.1	6.8-7.9	6.6-8.0
5	Suspended substances	11.1	13.6	10	20
6	Saline Ammonium	0.31	0.38	0.3	0.4
7	Nitrate Nitrogen	0.94	1.5	0.5	0.6
8	Nitrite Nitrogen	0.020	0.034	0.010	0.015
9	Phosphate Phosphor	0.116	0.06	0.03	0.05
10	Chemical oxygen demand (COD	30.4	36	25.0	30
11	BOD5	3.4	4.3	3.1	5.1
12	Dissolved oxygen	11	9.6	>7.6	>7.6
13	Iron	0.22	0.25	0.5	1.0
14	Copper	0.020	0.030	0.003	0.010
15	Zinc	0.027	0.032	0.020	0.050
16	Manganese	0.041	0.053	0.025	0.051
17	Nickel	n/d	n/d	<0.001	0.005
18	Chrome	n/d	n/d	<0.002	0.003

Table 9.. Values of difference between actual water quality of the Ikva River and environmental standards.

№ s/n	Indicators	Established ES for the Ikva river mg/dm³		Surface water quality ES for the Rivne Oblast, mg/dm³		Difference in values, mg/dm³	
		optimum	permissible	optimum	permissible	optimum	permissible
1	Chlorides	15.6	16.2	20	30	+4.4	+13.8
2	Sulphates	35.3	42.8	50	75	+14.7	+32.2
3	Total dissolved solids	523	562	500	750	-23	+188
4	pH	7.9	8.1	6.8-7.9	6.6-8.0	0	-1
5	Suspended substances	11.1	13.6	10	20	-1.1	+6.4
6	Saline Ammonium	0.31	0.38	0.3	0.4	-0.01	+0.02
7	Nitrate Nitrogen	0.94	1.5	0.5	0.6	-0.44	-0.9
8	Nitrite Nitrogen	0.020	0.034	0.010	0.015	-0.010	-0.019
9	Phosphate Phosphor	0.116	0.06	0.03	0.05	-0.086	-0.01
10	Chemical oxygen demand (COD)	30.4	36	25.0	30	-5.4	-6
11	5-day biological oxygen demand	3.4	4.3	3.1	5.1	-0.3	+0.8
12	Dissolved oxygen	11	9.6	>7.6	>7.6	+3.4	+2.5
13	Iron	0.22	0.25	0.5	1.0	+0.28	+0.75
14	Copper	0.020	0.030	0.003	0.010	-0.017	-0.020
15	Zinc	0.027	0.032	0.020	0.050	-0.007	+0.018
16	Manganese	0.041	0.053	0.025	0.051	-0.016	-0.002
17	Nickel	n/d	n/d	<0.001	0.005		
18	Chrome	n/d	n/d	<0.002	0.003		

10.4 Conclusions from the monitoring

1. The Ikva river water quality study shows that:
- the average and the worst values of the salt block indicators of the river water quality remain within the limits of category 1 class I;
- according to the tropho-saprobiological indicators the water quality falls into category 3 class II by the average values and into categories 3-4 class III by the worst values, correspondingly;
- according to the content of the specific toxic substances, copper, zinc and manganese are the key pollutants of the Ikva river. The block indices ranges from 2.2 to 3.5 by the average values and from 2.2 to 3.7 by the worst values of the indicators;
- the cumulative environmental index of the river water quality for the average values ranges from 2 to 2.4 and from 2.4 to 2.6 for the worst values and corresponds to the water quality class II.

2. With regard to the river pollution the analysis of dynamic curves of the cumulative water quality indicators shows slight shift of the environmental indices towards the worst values in 2003 and 2006.

3. On the basis of the categories calculated for the river water quality the optimum and permissible environmental standard values are established:
- for the salt block indicators ESo and ESp are established within the limits of categories 1-2, water quality class I-II, accordingly;

- for the tropho-saprobiological block indicators, they are established at categories 3-3.5 for the average values and categories 4-4.5 for the worst values that corresponds to water quality classes II and III, accordingly; for the nitrogen triad indicators (ammonia, nitrite and nitrate nitrogen) and for pollution of water by organic substances (according to BOD5) ESo are established within the limits of category 3.5 and ESp falls into category 4.5;
- according to the specific toxic substance indicators the water quality ESo and ESp are established within the limits of categories 1-5, water quality class I-III.

4. The river water quality is characterized by different levels of pollution along the course of the river due to different degrees of anthropogenic pressure.
5. The river water protection and rational use should be ensured by means of implementation of the water quality monitoring system and the integrated environment protection measures aimed at restoration of the ecosystem imbalance and improvement of its quality, which is in compliance with the EU Directive requirements.

11. Risk assessment

Preliminary risk assessment in the Ikva River Basin

On the whole the Prypiat' River basin, including the Ikva River basin, by now has suffered from significant transformations. For instance wide-scale draining melioration, separation of the flood-lands by the flood walls, rivers regulation and construction of the reservoirs and ponds, intensification of the forestry and agricultural activity, urbanization, recreational load and many other. For the Ikva River basin the main pressures are melioration (transformation of the river bed), waste waters discharge, pond fish culture, agricultural activities (probably including fertilizers, pest and weed-killer chemicals storage, to be specified), oil products discharge from the pipeline, peat extraction and waste water discharge, non-specific biological effects (possibility of the aquaculture objects invasion and all probable consequences for the native ecosystems).

In many sections of the Prypiat' and, consequently, Ikva River basin all these activities have extremely negatively effected the state of the natural complexes. Particularly, for the water bodies and associated wetlands was noted: drop in the ground waters level, drainage of the wetland massifs, arising of the new types of ecosystems (polders, ponds, ecosystems in the between-dam space), change of the natural ecosystems relation – swamps, lakes and rivers. Drainage of the significant areas and including them into the agricultural activity without integrated ecological basis led to the silting of the rivers and excess overgrowing by the higher aquatic vegetation. Income of the fertilizers and other pollutants with the surface flow, discharge of significant amounts of the industrial, municipal and agricultural waste water, physical alterations of the main stream and flood-land caused pollution of water, significant worsening of their hydrochemical and trophic status. That's why in the most rivers in the Prypiat river basin practically total transformation of the aquatic communities have occurred. All the above mentioned impacts caused first of all transformation of the pelagic communities (phyto and zooplankton), however in the communities of the higher aquatic vegetation, benthic communities and ichthyophauna are still in the intermediate state. In the most river system was noted decrease of the biological diversity, change of the dominating species complex, extinction of the rare, relict, oxyphilous and rheophilos species of the flora and fauna. Thus, many species of the mollusks, mayflies, caddis flies, character for clean water bodies at the moment are hardly to find. At the same time, as a result of eutrophication, at some sections numerical density and biomass of phyto, zooplankton, higher aquatic vegetation and zoobenthos sharply increased due to mass development of limited number of tolerant species. Among fish population first of all suffered rheophilous species. Quality of habitats of many limnophilous fish species also became worse because of forage base exhaustion, disturbance of the self-purification ability of the rivers, decrease of areas available for spawning, disturbance of the river continuum – and isolation of the fish populations. The last two reasons are peculiar also for the Ikva River, because it is regulated by the dam.
At the same time in the Prypiat' river basin remain unique, sometimes not disturbed or very slightly disturbed landscapes and biotopes with considerable concentration of the rare species of plants and animals. Such non-uniformity of the Ikva River stream and basin complicated its division into the sections – water bodies. Final characterization of the water bodies as “natural” of the appropriate type or “heavily modified” water bodies is of special importance. Adoption of the status entailed on the one hand, application of the different approaches to assessment of the ecological status/ecological potential, and on the other hand – determination of objects and costs for the water protection and environment protection activity in the basin.

Thus, in the future stages the following material and activities will be of significant importance as background for development of the Ikva River basin management plan and determination of the reference biological conditions:

- To carry out inventory of the rare, endangered and valuable species in the Ikva River basin (plants, invertebrates, fishes, amphibians, reptilians etc.)

- To determine important ecosystems (meadows, forests, wetlands – if any; protected areas).
- To carry out inventory of the biological diversity in all sections/water bodies.

Within the frames of some previous projects, leaded by Dr. S. Afanasyev, Institute of hydrobiology obtained some data on actual state of the Ikva River at some sections. Also data on biota of other rivers of the same type might be used for characterization.

Water bodies R1 and R2: Investigations have been carried out upstream village Sapanovchyk. River type: Small River in the calcareous bed on the highland.

Meadow flood land is well-developed, over wetted, almost in the natural state. It is moderately used as pastures and for hay-harvesting River width 20 m, depth – to 2.5 m, water transparency 1.0 m, velocity of flow 0.4 m/sec. Bottom sediments are mainly sand and silted sands. River bed is significantly over grown by higher aquatic plants (up to 40%), two-zone character of vegetation. In zone of the emergent plants dominated Typha and Gluceria maxima. Zone of the floating-leaves vegetation was up to 2.5 m width formed by Nuphar lutea. In ichthyophauna occurred Carassius carassius, Rutilus rutilus, Scardinius erythrophtalmus, Perca fluviatilis, Esox lucius and Blicca bjorkna.

Species composition of zoobenthos was quite diverse: occurred Ephemeroptera, Trichoptera, mollusks, Asellus aquaticus, Hirudinea, Chironomidae. Dominated Lymnaea auricularia.

Characteristic of the bottom fauna:

Dominant – Lymnaea auricularia

Species number in the indicative groups: Ephemeroptera – 2, Trichoptera – 2 Odonata – 2, Chironomidae - 4.

Trent biotic index TBI – 7

Water quality class according to bioindication – II (clean)

Trophic status – mesotrophic

In the lower part of the Ikva River investigations have not been carried out. However for the section R 5 it is possible to use data on the analogous river type: middle rivers in the siliceous riverbed on the lowland.

Flood-lands and riparian zone are intensively used as pastures, hay harvesting, construction and recreation. Vegetation of the flood-land is disturbed. River is about 30 m wide, up to 3 m deep, velocity of flow 0.1 m/sec, water transparence up to 2.5 m. Bottom sediments – silt, silted sand. Because of big shallow areas, low velocity of flow and high transparence higher aquatic vegetation is well developed; water area is overgrown up to 70%. Vegetation is of massive and zone-massive character, in the latter case 2–3 zones are noted: the first is formed by Glyceria maxima and Scirpus lacustris; the second is formed by Nuphar lutea; the third is formed by limnophilous submerged forms (Elodea canadensis, Ceratophyllum demersum, Batrachium sp., Lemna sp.). Up to 17 species of the higher aquatic plants were registered, among them significant portion of the swampy and limnophilous species, which are character for the water bodies of the elevated trophity. Notable vegetation of the green filamentous algae was also noted, which is a sign of the excess amount of the nutrients.

In ichthyophauna were noted: Blicca bjorkna, Perca fluviatilis, Rhodeus amarus, Gobio gobio, Cobitis taenia, Alburnus alburnus and Esox lucius.

In zoobenthos dominated Trichoptera (4 species). On the whole 12 indicative groups were registered, with high species diversity.

Species number in the indicative groups: Ephemeroptera – 1, Trichoptera – 4, Odonata – 1, Bivalvia – 2, Gammaridae, Gastropoda, Spongia - 3, Asellus aquaticus, Hirudinea, Sphaeriidae, Chironomidae, Oligochaeta.

Trent Biotic index TBI – 7

Water quality class according to bioindication – II (clean)

Trophic status – eutrophic.

For the section T2 it is also possible to use data on the analogous river type: small rivers in the siliceous riverbed in the highland.

Meadow flood-land is in almost natural state. Stream is transformed (canalized, straightened), 3 m wide, up to 1 m deep, velocity of flow up to 0.1 m/sec. transparence of water 0.4 m, bottom sediments mainly silts. Higher aquatic vegetation was presented mainly by emergent forms, which formed

narrow zone along the banks. Dominated Glyceria maxima or Phragmites sp. In the stream aquatic moss Fontynalis anthipyretica was noted. Ichthyophauna consisted of limited number of species: Gobio gobio, Leucaspius deliniatus, Alburnus alburnus, Rhodeus amarus, Rutilus rutilus, Perca fluviatilis.
Species composition of zoobenthowas was also poor. Dominated Simuliidae larva. Also occurred Ephemeroptera, Trichoptera, Chironomidae, Bryozoa, bivalves and snails, Asellus aquaticus.
Species number in the indicative groups: Ephemeroptera – 1, Trichoptera – 1, Odonata – 1, Bivalvia – 1, Gastropoda, Asellus, Sphaeriidae, Diptera, Chironomidae, Oligochaeta.
Trent Biotic Index TBI – 6
Water quality class according to bioindication – III (polluted)
Trophic status – mesotrophic.

As it was agreed, sections R1, R2 and R5 are in a good status and since do not need to be assessed in view of the probable risk of failing the environment quality objectives. However, as it was preliminary characterization, based on the expert consideration, and taking into account low predictability of the future development of the Ukrainian economics and one of the principles of the WFD – prevention of deterioration, it would be desirable to take in mind some notes.
Section R1. This section is in the best conditions. However, there are some settlements (at least 7 (source – the map of the Brody rayon http://www.brody.lviv.ua/maps/brody_rn_map.htm)). Most or even all of them have no centralized sanitary sewage system. Surface flow from agricultural areas also might serve as pollution factor.
Section R2. The section is located within the Kremenetsky rayon of the Ternopil oblast. The main load source might serve first of all the Kremenets town itself, located in the immediate closeness to the river. There are some industrial enterprises (particularly sugary plant, chalk plant, dairy canning factory, enterprise “Agrariy”, bakery, factory “Ikva”, etc., source: http://www.terinvest.com.ua/index.php?id=1090&show=5282). Additionally, there are some settlements, like those in the upstream section, they also have no centralized sanitary sewage system and agricultural activity is the main economics. Probably, some water is uptaken in this section and sure, above mentioned enterprises produce certain volume of the sewage waters. All of them were not mentioned in the list of water users (it comprises data only on the Rivne oblast’). One more factor which should be taken into account at this and downstream sections is presence of fishery ponds in some tributaries. Though their exploitation and level regime are regulated by rules, they may cause some effects, particularly water enrichment by nutrients and organic matters after seasonal water discharge, invasion of new alien species, appearance and distribution of diseases in case of the alien species invasion.
Section R3. This section is considered as being in the moderate status and has to be assessed in view of risk. The main hydromorphological impact at this section is transformation of the river bed and flood-land, drainage melioration, redistribution of the flow in some arms. Also some settlements are located within this section of the basin and all three relatively big tributaries, which also are considered as being in the moderate status also inflow within it. But probably the main impact is discharge of the waste water from some enterprises: Dubno municipal waste water treatment plant, sugar factory, dairy plant; their total volume of discharge 921.3 Mio m3. (Unfortunately, all data in the report are cited according to the administrative division. The most probably discharge of the waste waters from Dubno mainly affects the downstream section). At the same time significant vegetation of the higher aquatic vegetation in the flood-land between river arms may serve as powerful biofilter, which uptake nutrients. One more aspect of risk is a health-protective – in June 2009 sanitary-epidomiological station prohibited bathing in the river Ikva within the Dubno region because of the helminthes eggs (ascarids and whipworms) and Salmonella occurrence in water (information source: http://gazeta.ua/index.php?id=234527eid=633; http://www.zamok.ucoz.ua/news/2009-08-06-183). Such situation is caused by regular spills of the waste water because of pipe defects in the sanitary system.
Lower sections of two right-bank tributaries (T1 and T2) are also included into the ameliorative system “Ikva”. The upper sections pass through the peat-extraction and agricultural regions. These

activities negatively affect quality of water (excess amount of the humic matters, coloration of water worsen quality of water itself and quality of habitats, surface inflow from agricultural areas cause eutrophication). Small left-bank tributary crosses areas with high density of settlements and intensive agricultural activity.

As it is mentioned in the report, the Ikva River within the Rivne oblast' is crossed by 5 pipelines: 2 oil, 2 gases and 1 oil-product. Taking into account that most of pipelines are outmoded, probability of the accidents also should be taken into account.

Section R4. This section is mostly affected by the previous, though the river bed is not transformed. The natural river flow is capable of self-purification.

It seems that risk of failing the environment quality objectives at two above-mentioned sections is similar and will depend first of all on state of the facility of all industrial enterprises and waste-water treatment plants.

Section L1. The Mlynivske reservoir is considered as being in the moderate status. It is affected by the load from the upstream sections, significant recreational activity and superficial flow from the agricultural areas. According to some data (source http://provinciyka.rv.ua/index.php?newsid=4177) in periods of high water the reservoir cause underflooding of the upstream areas, including the Dubno town, because since fifty years of exploitation working volume in the reservoir decreased up to three times, and consequently, its accumulative and regulative capacity dropped. So reservoir should be cleaned. There are some propositions to settle plant-feeding fish into the reservoir with the aim of its biological purification. Such propositions should be considered as risk factor, because settlement of the alien plant-feeding fishes without scientific background may cause unpredictable consequences for the ecosystem of the reservoir and downstream section of the Ikva River. The same article contain information about importance to "clean and to deepen" the river bed, such activities also may be considered as risk factor, because often it means only dredging the river bed by machinery. However, in this section failure of the ecological objectives may be explained by social purposes, because of its role in the flood regulation and accumulation of nutrients.

Section R5. This section is considered as being in the good status, though it is under the effect of all upstream and superficial flow as well. Waste water of some industrial enterprises of Mlyniv (dairy, cannery; source: http://www.irp.rv.ua/resursi/administrativno-teritorialnii-ustrii/mlinivskii-raion) and municipal waste waters overload the reservoir (L1) and may affect it. However this section is of natural character of the river bed and, consequently, there are more diversity of biotopes, in the lower part it interrelate with the bigger river (Styr) – this is especially important for development of the fish communities.

On the whole it should be mentioned, that according to report of the Rivne authority (p. 48 of the Ukrainian variant) water uptake from the river in 2008 amounted to 12.75 Mio m3, and discharge – to 9.41 Mio m3, moreover, as it was mentioned this water was not sufficiently purified. Such situation also may cause some disturbances in the river system functioning. Number of the cows and swine also should be accounted for risk assessment.

So, as it is mentioned in the paragraph 13 of the Initial prepositions of the WFD "…Decisions should be taken as close as possible to the locations where water is affected or used". More adjusted risk analysis will need more detailed data on impacts and pressures within all the river basin, in three oblasts'. In general it may be concluded that at the actual situation in waste water treatment and protection of the surface water bodies there is risk of deterioration of the ecological status. But without a field survey and detailed invention of all probable sources of pollution and disturbance it is hardly to make precise predictions.

12. Final list of water bodies and their risk of not reaching good ecological status

12.1 Surface water bodies

This list was achieved during the workshop in Rivne in December 2009 (and confirmed in March 2010) based on the judgment of a panel of approximately 15 water experts, see **Figure 23** and **Table 10**. Water bodies with yellow color are found to at risk of not meeting the WFD requirement of good ecological status.

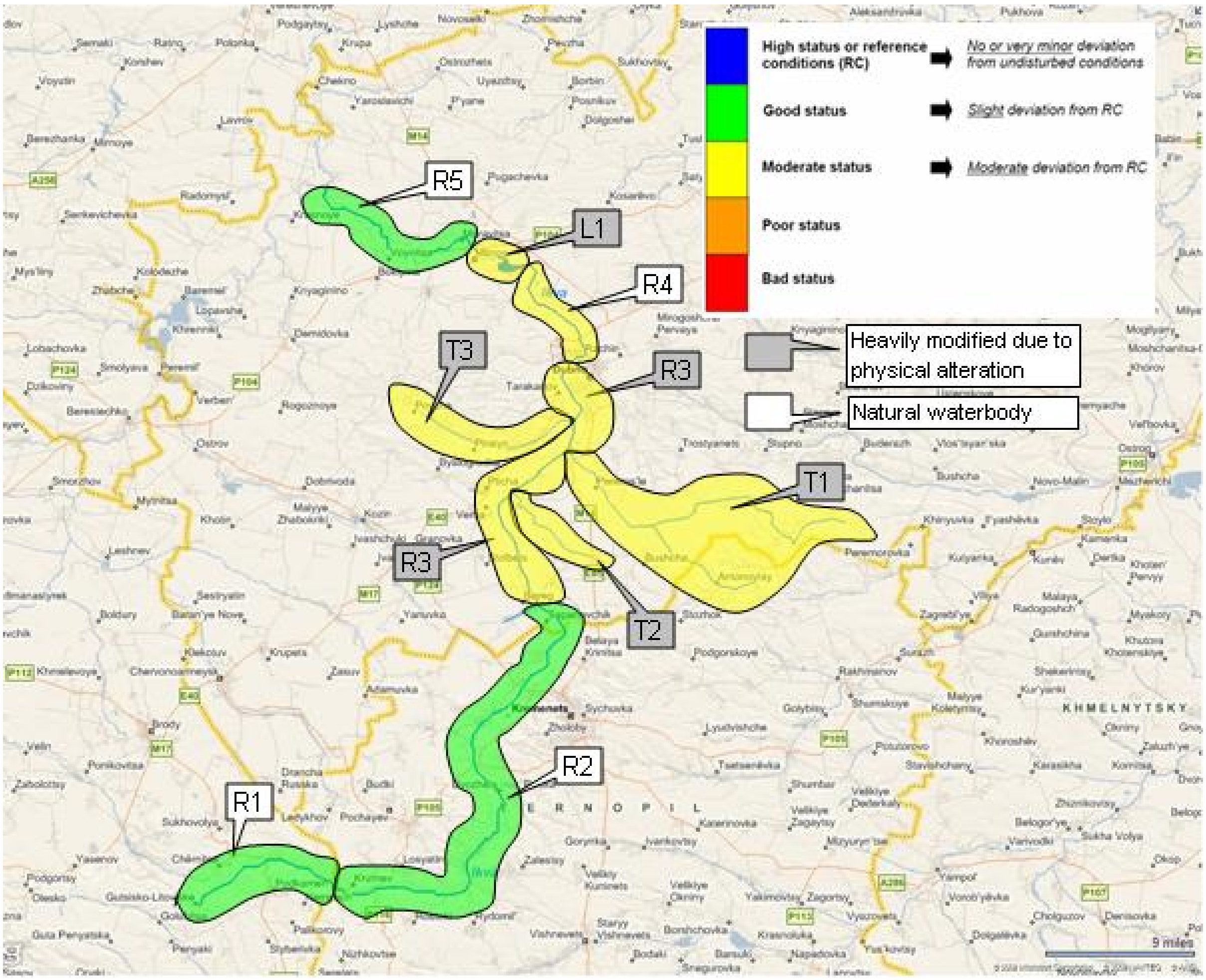

Figure 23. Water bodies of Ikva River identified at the work shop in Rivne in December 2009. R=river, T=tributary, L=lake.

There are performed few ecological studies in the Ikva River, so this first characterization should be validated by relevant monitoring studies. Some of the water bodies have been studied this summer (2010) as part of this project, and the results are soon clear.

Table 10. Surface Water bodies in Ikva River Basin, as decided in the workshop in Rivne Dec 3-6 2009 and confirmed in March 2010.

Code	Description	HMWB	Status
R1	The upper river stretch in Lviv, low pollution load, no physical impact	No	Good
R2	The upper part of the river in Ternopil. The river is straightened, low pollution load	No	Good
R3	The river stretch from Bereg to Dubno. The river is dammed, and heavily impacted by canalization from the Ikva drainage system. Polluted from settlements, peat extraction, fish farming and agriculture	Yes	Moderate
T1	Tributary. Heavily drained and modified by peat extraction	Yes	Moderate
T2	Tributary. Heavily drained and modified by agriculture and by peat extraction	Yes	Moderate
T3	Tributary. Heavily modified due to fish farming and agriculture	Yes	Moderate
R4	The stretch of Ikva River between Dubno and the Mlyniv Lake	No	Moderate
L1	Mlyniv Lake, man made reservoir due to damming of the river	Yes	Moderate
R5	The stretch of Ikva River from Mlyniv and down to the confluence with Styr River. Natural meandering river	No	Good

12.2 Ground Water Bodies

The groundwater is evenly distributed over the whole catchment and can be regarded as on single water body. The ground water table is lowered 1-2 m because of heavily drainage of agricultural land, but is still plentiful. The chemical status is good, despite some signs of increased salt concentration can be observed in deeper zones, mainly due to oxidation processes in the soil as a result of extensive drainage. Excess of nitrates can also be observed in some areas, and likely also traces after pesticides used in the agriculture.

13. Monitoring programme

13.1 Introduction

The WFD describes three types of monitoring programmes

1. Surveillance monitoring
2. Operational monitoring
3. Investigative monitoring

Surveillance monitoring should be used to monitor the national reference water bodies to assess the large scale alterations due to e.g. climate changes, atmospheric fall out, etc. It should cover the different water types of the national typology system. It could also include a few impacted water bodies if necessary to improve the classification system. The surveillance monitoring should comprise all five biological quality elements as well as chemical analysis relevant for typology, nutrients, and environmental toxins that are spread via atmospheric fallout. The goal of the surveillance monitoring is to improve the basis for assessing the reference condition in the different water types, to assess the large scale trends which are not caused by local discharges, as well as to improve the classification system.

Operational monitoring should be used to monitor the impacts of human activities within the catchment of each water body. It should be used to assess (verify) the status of each water body that was evaluated as “at risk” or “possibly at risk” in the characterisation. It should be used to assess the need for abatement measures, and to monitor the effect of the measures that are implemented. This monitoring should be performed until the water body are brought back to a stable position within the class of good ecological status. The operational monitoring should comprise the (or those) biological quality elements that are deemed best to describe the impact of the pressure that a particular water body is exposed to. The same apply for the chemical parameters. Unlike the surveillance monitoring, the operational monitoring does not need to comprise all the biological quality elements. Normally in the European countries, about two biological quality elements are included on average in the operational monitoring. If it is found necessary, sometimes three biological quality elements are included, sometimes only one, but very seldom all five.

<u>The operational monitoring is the type of monitoring that should be conducted in Ikva River.</u>

Investigative monitoring should be performed if something is wrong with one ore more of the biological quality elements, but the reason is not known, e.g. a sudden fish kill or algal bloom, etc. This should include the parameters that are most relevant for the observation, both with respect to biological and chemical parameters.

In Ikva River it is **operational monitoring** that should be performed, and what this programme will deal with in the proceeding section.

13.2 Programme for operational monitoring of Ikva River

The WFD set up certain rules for how the different monitoring programmes should be carried out, with respect to monitoring stations, parameters and sampling frequencies for the different parameters, as well as duration of a study. In this demonstration project we do not find it possible to conduct a full monitoring programme, as there will only be time for one sampling.

13.2.1 Type of pressures

The selection of parameters, sampling stations, as well as sampling frequencies should be relevant for describing the impact of the pressure which the water bodies are exposed to.

The main pressures that the Ikva River are exposed to are

1. Eutrophication due to discharges of nutrients and organic matter from sanitary effluents and agricultural runoff
2. Hydro morphological impact from damming and drainage, canalisation and straightening

A potential additional pressure may be caused by runoff of pesticides from the agricultural fields. There are no heavy industry centres in the area that discharge environmental toxins of notable amounts.

The groundwater is also potentially impacted by pesticides and from nitrate from the agriculture, but ground water monitoring has not been discussed yet in this programme.

13.2.2 Monitoring stations

In our characterisation work it was agreed that the Ikva River should be divided into 11 water bodies, 7 in the main stream river channel and 3 tributaries, see **Figure 24**. In the workshop in Rivne 24-25 March it was found necessary to include the monitoring stations given as red circles in the same figure.

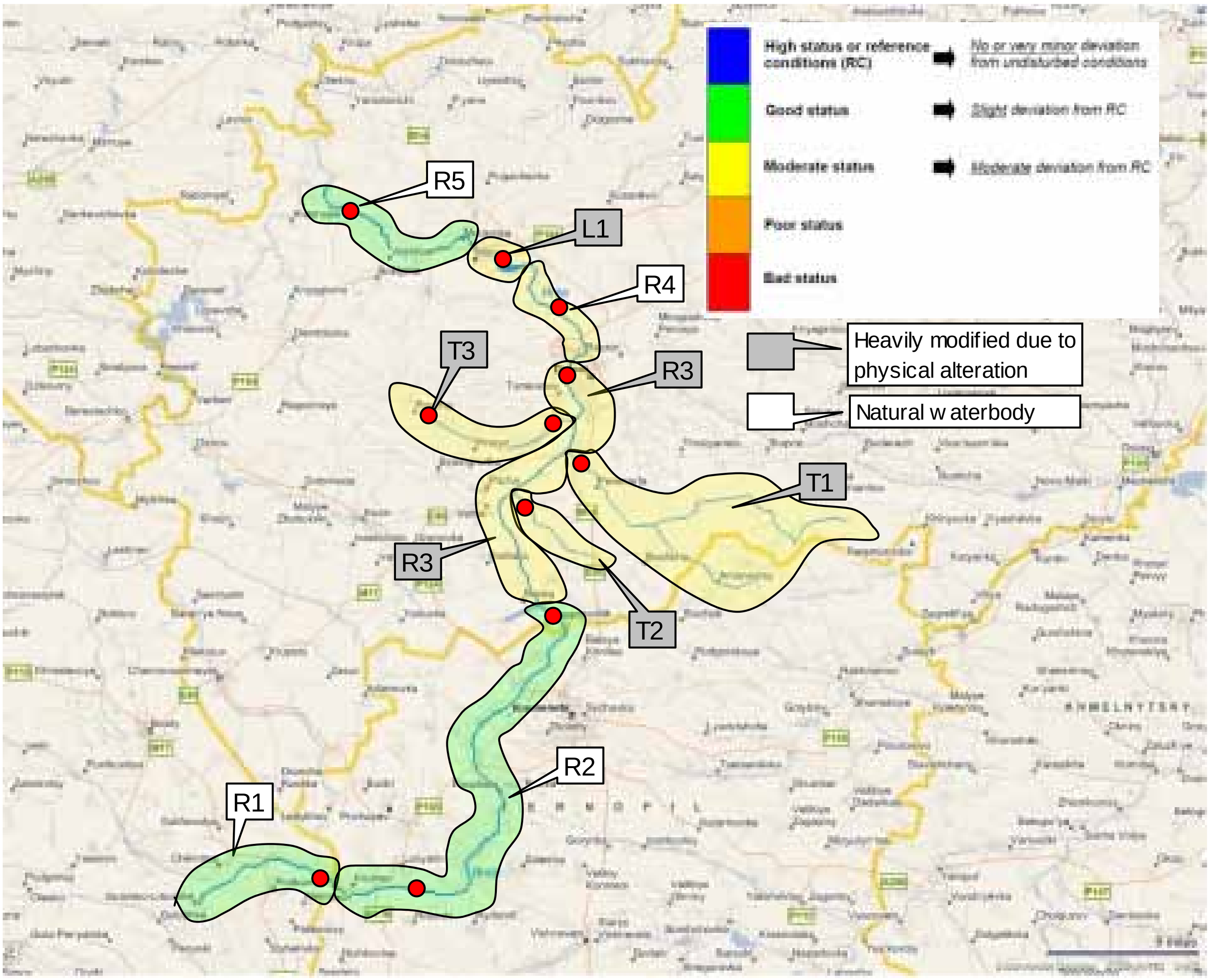

Figure 24. Water bodies and monitoring stations in Ikva River.

According to the WFD it is not necessary to monitor water bodies that are in good ecological status, or have no risk of not meeting that requirement. This means that it is not required to monitor the water bodies R1, R2 and R5 if our characterisation work is correct. It was, however, mentioned that the classification of these water bodies as having good ecological status was relatively insecure due to lack of data. It was therefore recommended to include monitoring also in these the first year of monitoring. They could be taken out afterwards if the status were found to be good.

The arguments for the monitoring stations are as follows:

R1 is the upper stretch of the river, and is little impacted by human discharges. It is also upstream of the stretches that have been impacted by hydro morphological encroachments. The monitoring station at the outlet of this stretch may partly serve as a reference for the more impacted stretches of the river.

In the river stretch R2 it is proposed two monitoring stations, R2-upper and R2-lower. R2-up is only slightly impacted by a few fish ponds and by straightening of the river channel, whereas R2-lower also includes the discharges from the Kremenets city. This latter may have the potential of moving the status of the river down one quality class.

In R3 the river is impacted by fish ponds, by draining including locks and gates and polder systems (Ikva drainage system), and by peat extraction. The lower border of the water body is at a dam near Dubno that is regarded as a fish migration barrier. This dam is just upstream of the discharges from Dubno city. The monitoring station at the lower end of this water body will give information on the status of this stretch of the river, and about the impact of the human activities connected with peat extraction and fish cultivation. In addition it will serve as a reference for the discharges from Dubno.

Three tributaries are draining to the river in this area. All these are polluted from human activities. Those coming from the right, T1 and T2 are both impacted by peat extraction, while the one from the left, T3, is impacted from large scale fish farming as well as agriculture. These are identified as separate water bodies, and it is recommended to have one monitoring station in the lower part of both T1 and T2, and two monitoring stations in T3, one upstream and one downstream the fish farming stretch.

The river stretch R4 is between the Dubno dam and the Mlyniv Lake. The discharges from Dubno city enter the river here. Compared to the stretch upstream, R3, the river is not much disturbed of drainage and polder systems in this stretch. It is recommended to have a monitoring station in this stretch, with the aim of both describing the status of the water body, and give information on the total load of nutrients and other pollutants.

L1 Mlyniv Lake is a man made reservoir originally created for hydropower purposes. It is the only lake in the main Ikva River. The dam creates a fish migration barrier and makes the fish fauna upstream poorer in diversity than it would otherwise have been. The lake shows clear signs of eutrophication, with algal blooms and nuisance growth of aquatic macrophytes. The status is classified as moderate. It is recommended to have a monitoring station in the lake.

The lowermost stretch of Ikva, from the Mlyniv dam to the confluence with Styr River, is also identified as a separate water body. The status is anticipated to be good, but there is some risk for it to be moderate. Therefore it is recommended to have a monitoring station at Torgovitcha just before it enters the Styr River. Here the river contain the fish species that would have inhabited much of Ikva River if the dams had not been built, thus it can serve as a reference for this biological quality element. With respect to the content of pollutants, it gives information on the amount which Ikva send into Styr River, as well as discharges from Mlyniv city.

13.2.3 Monitoring Parameters

The monitoring parameters should be related to the impact that the river is exposed to. The main impacts in Ikva River are eutrophication and hydro morphological encroachment.

To describe eutrophication in fast running waters, the most common biological parameters are BMI (benthic macro invertebrates), and attached algal growth (periphyton). In slow flowing rivers it is more common to use phytoplankton and chlorophyll-a, than periphyton. Fish is often regarded as the best biological parameter to monitor impacts of hydro morphological alterations in a river.

In the workshop in Rivne in March it was discussed parameters and it was concluded that to be able to describe the status of the different water bodies, the parameters given in **Table 11** should be studied. With respect to the biological quality elements, this proposal is, however, more comprehensive than what is required according to the operational monitoring in the WFD. A country is of course free to include more than the minimum requirements, but in the practical operational monitoring that has been started in Western Europe after the WFD, seldom include more than two biological quality elements. In the table it is given a proposal for prioritising by give the most important parameters red colour and the more optional parameters normal black colour. Chlorophyll-a is included most places as this analysis is much less laborious than the other biological parameters.

Table 11. Monitoring parameters at the different sampling stations in Ikva River. Proposal from the workshop in Rivne 24-25 March. See figure 1 for localisation.

Station	Biol	Chem	Phys	Microbiol	Priori. C	HMWB?	Frequ
R1	BMI, Chl-a,	TP, TN, Coulor, Ca, BOD_5, O_2	Q, Width, depth			No	
R2-up	BMI, Chl-a, Phyt-pl, Fish, Macrophyt		Width, depth			May be	
R2-Lo	BMI, Chl-a, Phyt-pl, Fish, Macrophyt	TP, TN, Coulor, Ca, CODcr, BOD_5, O_2	Q, Width, depth	E.coli, Clostridiun perfringens		No	
R3	BMI, Chl-a, Phyt-pl, Macrophyt	TP, TN, Coulor, Ca, CODcr, BOD_5, O_2	Q, Width, depth	E.coli, Clostridiun perfringens		May be	
R4	BMI, Chl-a, Phyt-pl, Fish, Macrophyt	TP, TN, Coulor, Ca, CODcr, BOD_5, O_2		E.coli, Clostridiun perfringens	Heavy metals, select. org micro Poll	May be	
R5	BMI, Chl-a, Phyt-pl, Fish, Macrophyt	TP, TN, Coulor, Ca, CODcr, BOD_5, O_2	Width, depth	E.coli, Clostridiun perfringens	Heavy metals, select. org micro Poll	No	
T1	BMI, Macrophyt,	Heavy metals,	Q, Width, depth	E.coli, Clostridiun	Heavy metals,	May be	

		select. org micro Poll		perfringens	select. org micro Poll		
T2							
T3-up	BMI, Phyt-pl	TP, TN, Coulor, Ca, CODcr, BOD_5, O_2	Q, Width, depth				
T3-Lo	BMI, Phyt-pl	TP, TN, Coulor, Ca, CODcr, BOD_5, O_2	Q, Width, depth				
L1	Cl-a, Phyt-pl, Fish,BMI, Macrophyt,	TP, TN, Coulor, Ca, CODcr, BOD_5, O_2	Q	E.coli, Clostridiun perfringens	Sediment Fish flesh	May be	

13.2.4 Frequency of sampling

The WFD says that the member states should take as many samples that are needed to give a representative classification of the water body. It is given some minimum frequencies of sampling which are shown in the **Table 12** below.

Table 12. Minimum sampling frequency for the different quality elements in operational monitoring

Quality element	Rivers	Lakes
Biological		
Phytoplankton	6 months (i.e. twice a year)	6 months
Other aquatic flora	3 years	3 years
Macro invertebrates	3 years	3 years
Fish	3 years	3 years
Hydromorphlogical		
Continuity	6 years	
Hydrology	Continuous	1 months
Morphology	6 years	6 years
Physico-chemical		
Thermal conditions	3 months	3 months
Oxygenation	3 months	3 months
Salinity	3 months	3 months
Nutrient status	3 months	3 months
Acidification status	3 months	3 months
Other pollutants	3 months	3 months
Priority substances	1 months	1 months

The different parameters have different optimum periods for sampling which should be taken into account when planning a monitoring programme. This is particularly important when the minimum frequencies are used.

13.3 What shall be monitored in Ikva during the mission 15-16 June 2010

During the GEF Dnjepr project, Ikva River will be visited for monitoring in June as part of the larger programme. The programme outlined above will probably be too comprehensive to be possible to conduct during two days. We will therefore propose a reduced programme.

13.3.1 Reduced number of stations

Station R1, R2-lower, R3, T1, R4, L1, R5 (see map **Figure 24** and **Table 11**), i.e. seven stations are proposed to be included. Six of these are running water stations, and one is a lake station.

13.3.2 Samples and parameters at the Running Water stations

Biological samples: BMI, chlorophyll-a, phytoplankton, Fish (It is believed that it will be too laborious to carry out representative fishing in this mission, and it could be skipped. If you find it possible to include, it should be taken at station R3, R4 and R5)

Chemical parameters: Total-phosphorus, phosphate, Total-nitrogen, nitrate, ammonium, Ca, Mg, Colour, BOD_5, COD_{Mn}, COD_{Cr}, TOC, Fe, Mn

Prioritised compounds: Hg, Cd, Cu, Ni, Cr, Zn, Sn, Co, Sum pesticides (if available analysis technique), Chlorinated pesticides (if available technique), PCB.

Samples of bottom animals should be taken by the kick-method (3x1 minute), or by grab if the water is to deep to wade. Phytoplankton is taken quantitatively and fixed by lugols solution (or formalin) and species composition and bio volume, as well as percentage of blue green algae should be given.

13.3.3 Samples and parameters at Lake Mlyniv

The samples should be taken at the lake’s deepest point. It should be taken as a mixed sample representing epilimnion (0-3 m deep). From this sample all analyses as in the samples from the running water should be taken, minus bottom animals, and fish. Oxygen and temperature should also be measured along a vertical gradient from the surface to the bottom (at least 5 point measurements evenly distributed with the depth). On the same points it should be taken samples for total phosphorus and phosphate to see if there is any leakage from the sediments.

It should be taken five bottom grabs for analysis of bottom animals. Two of these should be taken in the deepest area, and three just outside the vegetation belt (sublitoral zone). The bottom animals should be analysed at least to family so the ASPT index could be calculated.

It should be taken a sediment sample from the deepest point, and analysed for water/dry matter, organic/inorganic content, as well as for the prioritised compound as given for the running water stations.

It should be caught 5 big carnivorous fishes (e.g. pike, perch, catfish, pikeperch) in lake Mlyniv and the flesh analysed for the prioritised compounds given above.

13.3.4 Treatment of data and evaluation of results

Until a new nationally adapted WFD-based evaluation system is in place, the treatment of data and evaluation of result should use the national system which are in use in Ukraine to day. The ecological status should be classified into 5 classes synonymous with the classes in the WFD-system.
The new data should be used to verify or modify the preliminary classification and risk assessment made in the characterisation report.

14. Monitoring results

The monitoring expedition was carried out the 15-16th of June 2010 by the Ukrainian team. The biological study was lead by the Institute of Hydrobiology and comprised sampling of phytoplankton and zoo benthos, whereas the chemical sampling and analysis was carried out by the State Environmental Inspectorate in the Rivne Region. The most important results are given an evaluation in the text below, whereas all analyses are given in the primary tables in the appendix.

14.1 Calcium – humic matter – water type

Ikva River is a calsium rich river with calcium concentrations varying from 80-200 mg Ca/l. pH is above neutrality and varies around 8. The humic content varies from a colour of 55 mg Pt/l to 68 mg Pt/l which indicate that the river is moderately impacted by humic material (peat and bog-runoff). The conductivity is high varying from 37 to 48 mS/m. The turbidity varies from 43-65 FNU, which indicate that the river is moderately impacted by erosion matter.

14.2 Algal biomass

The algae are identified to species and the number per litre is quantified by counting, where after the bio-volume is calculated. Assuming specific weight of unity, e.g. the same as the water they float around in, the results are converted to mg/l. The results are given in **Figure 25**.

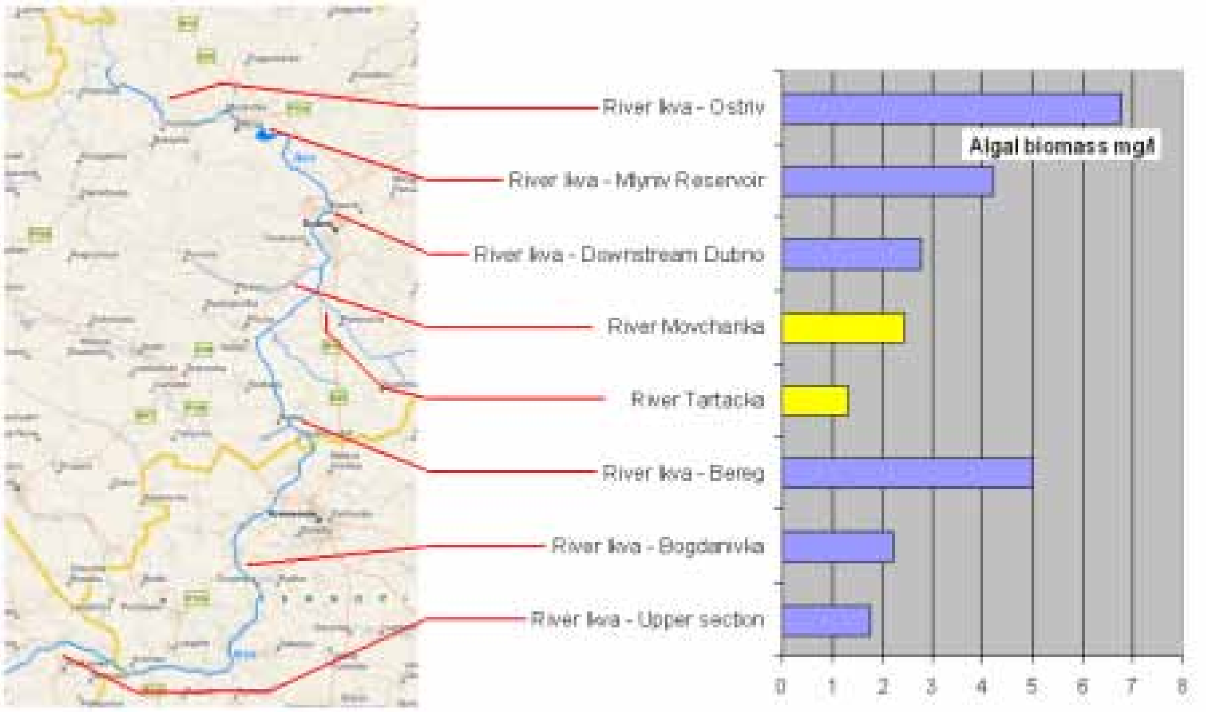

Figure 25. Biomass of phytoplankton at different sites in Ikva River 15-16 June 2010

The highest biomass was observed at the lowermost station before the junction with the Styr River, and at the station at Bereg. The first one of these is downstream of the discharges from Krementz town, and the lower one is downstream of the discharges from Mlyniv town. Thus, at these stations the water contains plenty of plant available nutrients. The biomasses are within the eutrophic level. Also the Mlyniv Lake has high algal biomass within the eutrofic level. About 50 % of Mlyniv Town is not connected to the sewerage systems and most of this sewage ends up in the Mlyniv Lake. The connected part of the sewage is discharged to the outlet of the lake. The other stations had lower algal biomasses, and were less impacted by eutrophication. However, most stations have running waters and as such the phytoplankton growth has some physical limitations.

14.3 Dissolved oxygen

The concentration of dissolved oxygen is shown in **Figure 26**. The Mlyniv Lake and the Povchanka Tributary both have very high oxygen concentrations, in fact a super saturation which is caused by high photosynthesis in the lake water and likely in the fish ponds of Povchanka. The stations at Bereg and downstream of Dubno has suppressed oxygen concentrations due to easy degradable organic matter in the discharges from Kremenetz and Dubno, respectively. The other stations had normal oxygen concentrations.

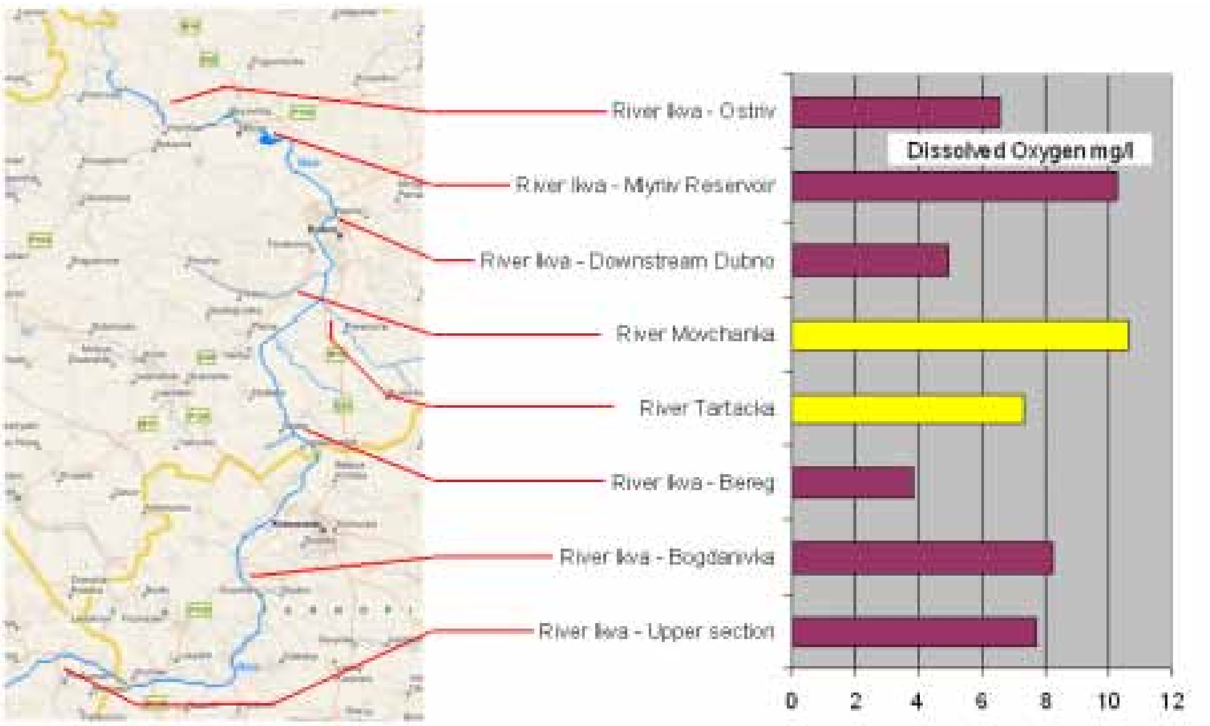

Figure 26. Oxygen concentration at different sites in Ikva River 15-16 June 2010

14.4 BOD and COD

The biological oxygen demand of the water is shown in **Figure 27**. In unpolluted rivers it is normally between 1 and 2 mgO/l. Mlyniv Lake and Povchanka tributary have clearly elevated levels of BOD, in the first place due to untreated sewage from Mlyniv Town, and in the second place most likely due to organic waste from the fish farm ponds. The station at Bereg has also elevated levels of BOD due to sewage discharges from Kremenetz Town.

The chemical oxygen consumption (**Figure 28**) of the water is related to the total amount of organic matter in the water, both arising from human discharges, manure, industrial discharges, but also natural humic matter coming from the catchment. The COD also oxidises the particulate organic matter, as e.g. algal cells, which are normally only partly included in the BOD. There is a general increase in the content of organic matter from the upper section to the lower sections of the river, indicating increased impact from human discharges, humic discharges (from the peat extraction) and river productivity, revealed through increased algal biomass.

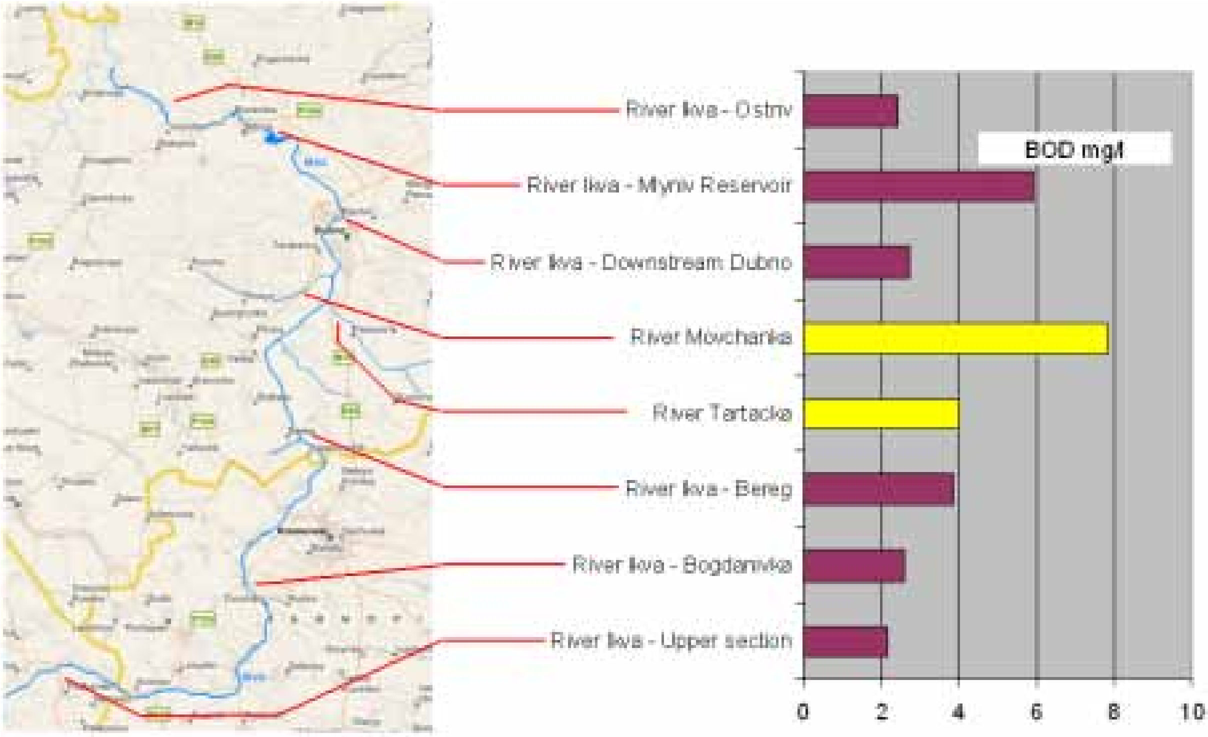

Figure 27. BOD_5 at different sites in Ikva River 15-16 June 2010

Figure 29 shows the ratio between BOD/COD as percentage. This gives an impression how much of the organic matter is easily degradable, i.e. the fraction that is depriving the river of oxygen. It is quite clear that the Mlyniv Reservoir receives untreated sewage or industrial effluents which contain easily degradable compounds, as e.g. sugar. The Povchanka tributary also contains easily degradable organic matter, most likely from the fish farming, but may be also from the manure and sewage. The other stations showed moderate degradability of the organic material.

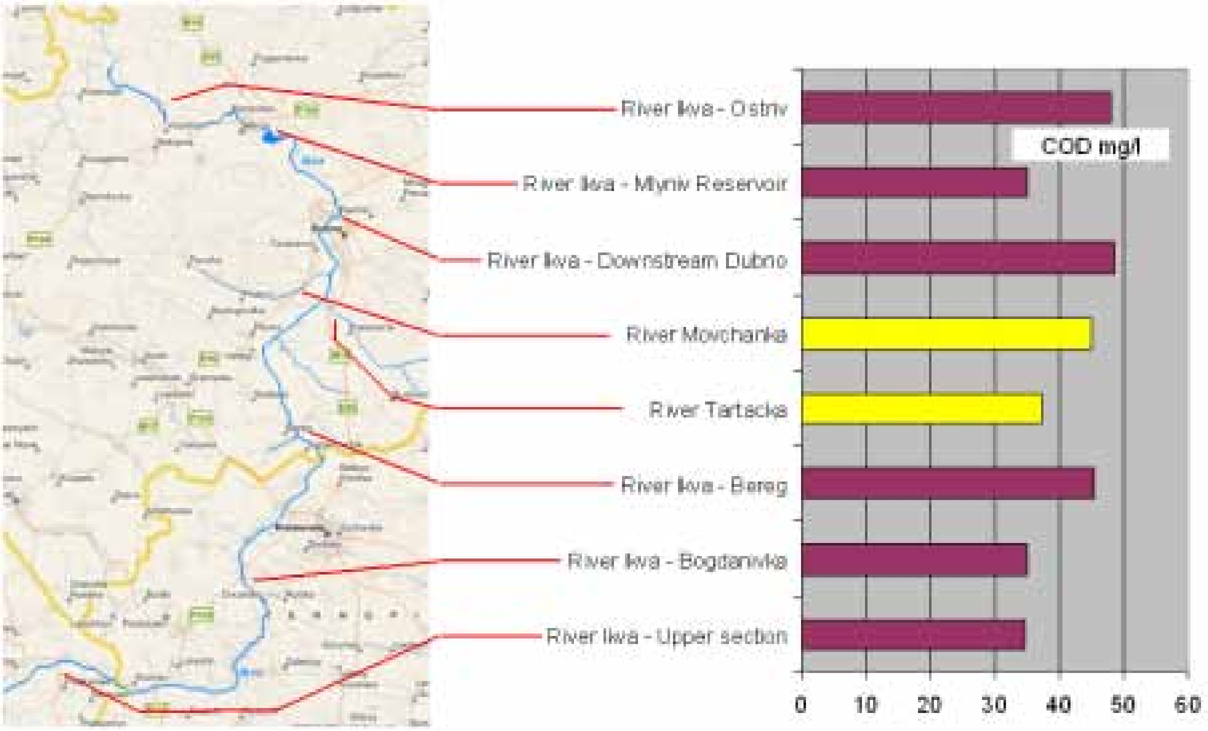

Figure 28. COD_{cr} at different sites in Ikva River 15-16 June 2010

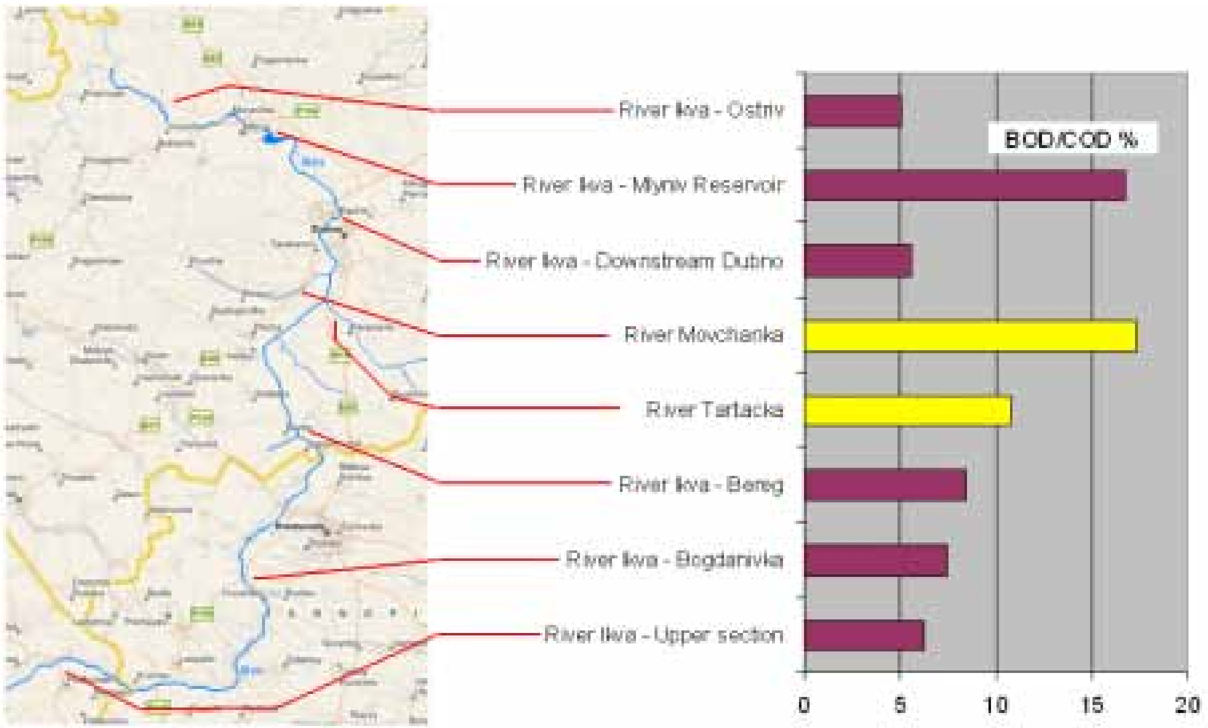

Figure 29. BOD/COD ratio in % at different sites in Ikva River 15-16 June 2010

14.5 Nitrate and Nitrite

The concentrations of nitrate and nitrite are shown in **Figure 30** and **Figure 31** respectively. Nitrate is the stable form of mineral nitrogen in the nature in contact with oxygen, and ammonium is the stable form in absence of oxygen. Nitrite is unstable and indicates fresh discharges where it is found in significant concentrations. Nitrate is found in very high concentrations at Bereg and in Mlyniv Reservoir. This is due to discharges from Krementz and direct discharges from unconnected sewage from Mlyniv Town. The nitrite concentration is particularly high at the Bereg station, but also elevated at the two other stations downstream the sewage discharges from Dubno and Mlyniv respectively.

The laboratory in Rivne does not analyse for total nitrogen, which is a central parameter in the WFD. Therefore one water sample from the upper station and one from the lower station were brought to Norway for analysis of Tot-N. The results were 1,03 mg N/l and 2,07 mg P/l respectively. These indicate that the river is only moderately impacted by pollution of nitrogen. The nitrate analysis from the laboratory in Rivne is given as mg NO_3/l and should be multiplied by 0.226 to give mg N/l, which is international standard.

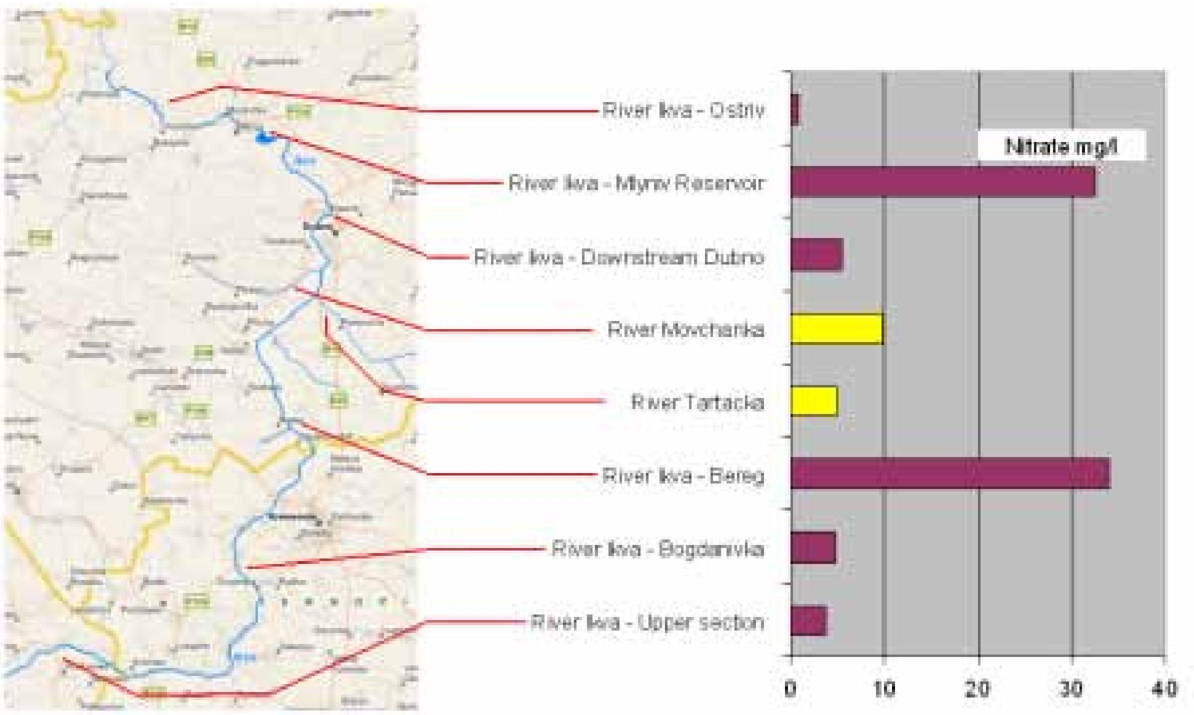

Figure 30. Concentration of nitrate at different sites in Ikva River 15-16 June 2010

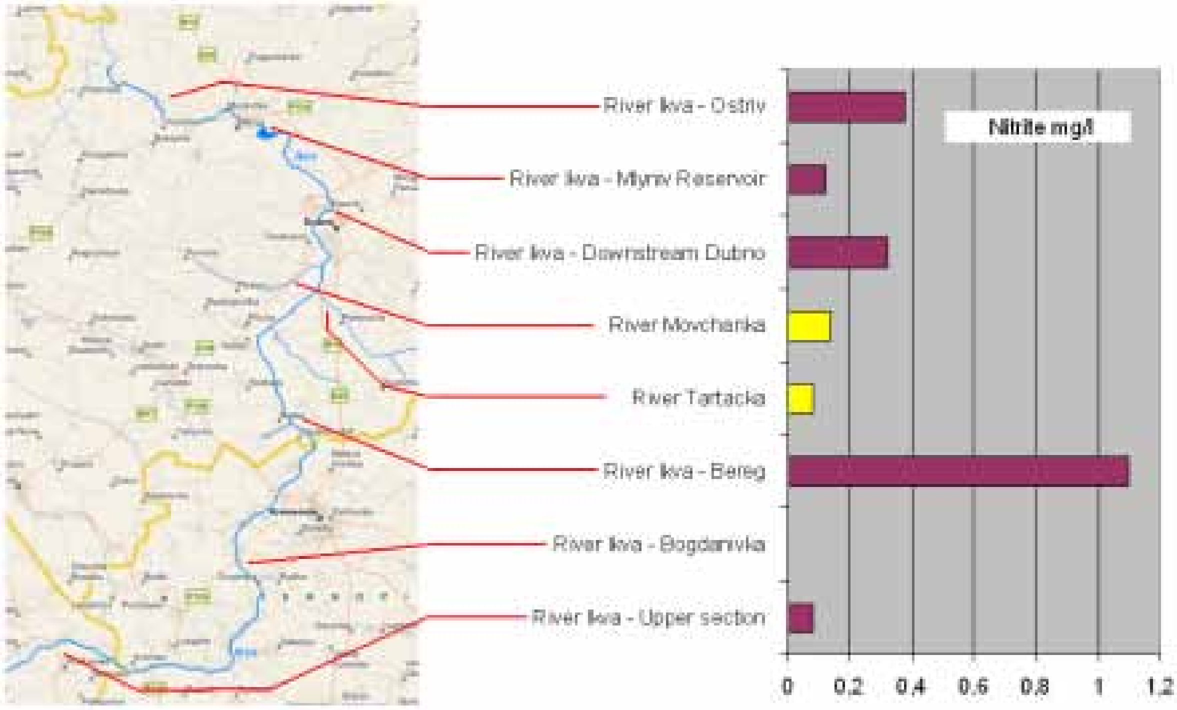

Figure 31. Concentration of nitrite at different sites in Ikva River 15-16 June 2010

14.6 Phosphate

The concentration of phosphate is given in **Figure 32**. The highest concentrations are observed at the stations downstream the discharges from the tree cities along the river, at Bereg (effluent from Kremenetz) downstream of Dubno city, and at Ostriv, downstream the effluents from Mlyniv Town.

The laboratory in Rivne does not analyse for total phosphorus, which is a very central parameter in the WFD. Therefore one sample from the upstream and one from the downstream of Ikva River was brought to NIVA for analysis. At the uppermost station the Tot-P concentration was 207 µg P/l, and at the lower it was 102 µg P/l. These indicate that the river is relatively eutrophic in all stretches. The values from the laboratory in Rivne is given as mg PO_4/l and needs to be multiplied by 0.326 to be converted to mg P/l , which is now the international standard and used in the WFD.

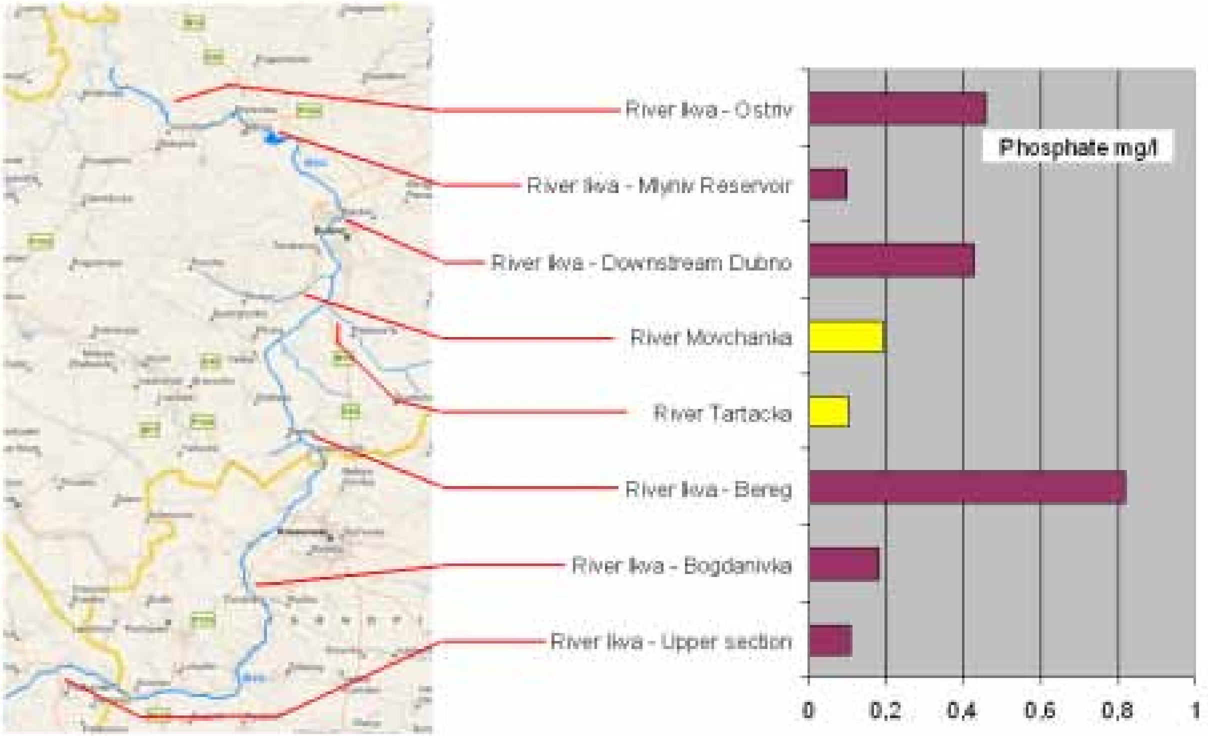

Figure 32. Concentration of phosphate at different sites in Ikva River 15-16 June 2010

14.7 Turbidity and suspended solids

The laboratory in Rivne does not analyse for turbidity which is a very central parameter in the WFD. Therefore a sample from the upstream and one from the downstream river stretches were brought to NIVA for analysis. The turbidity at the upstream and downstream stations was 65 FNU and 43 FNU respectively, a level that clearly gives the water a turbid look. This indicates that the water is moderately loaded by particles, which can be both erosion material and algae.

The concentration of particulate matter in the water of Ikva (suspended solids) is shown in **Figure 33**. The concentration is relatively low at all stations indicating that Ikva is not impacted much from erosion products. Concentration of 2 mg/l must be regarded as natural level. It is only the tributaries that have values that indicate significant impact from human activity, and particularly Tartacha tributary which is impacted by peat extraction. The laboratory in Rivne is using a paper filter of mean retention of several µm, whereas the international standard uses glass fibre filters, with retention 0.8 µm. The coarse paper filter used in the monitoring under-estimate the true amount of particulate matter in the river water. The glass fibre filters can also be ignited which allows for differentiating between inorganic and organic particles.

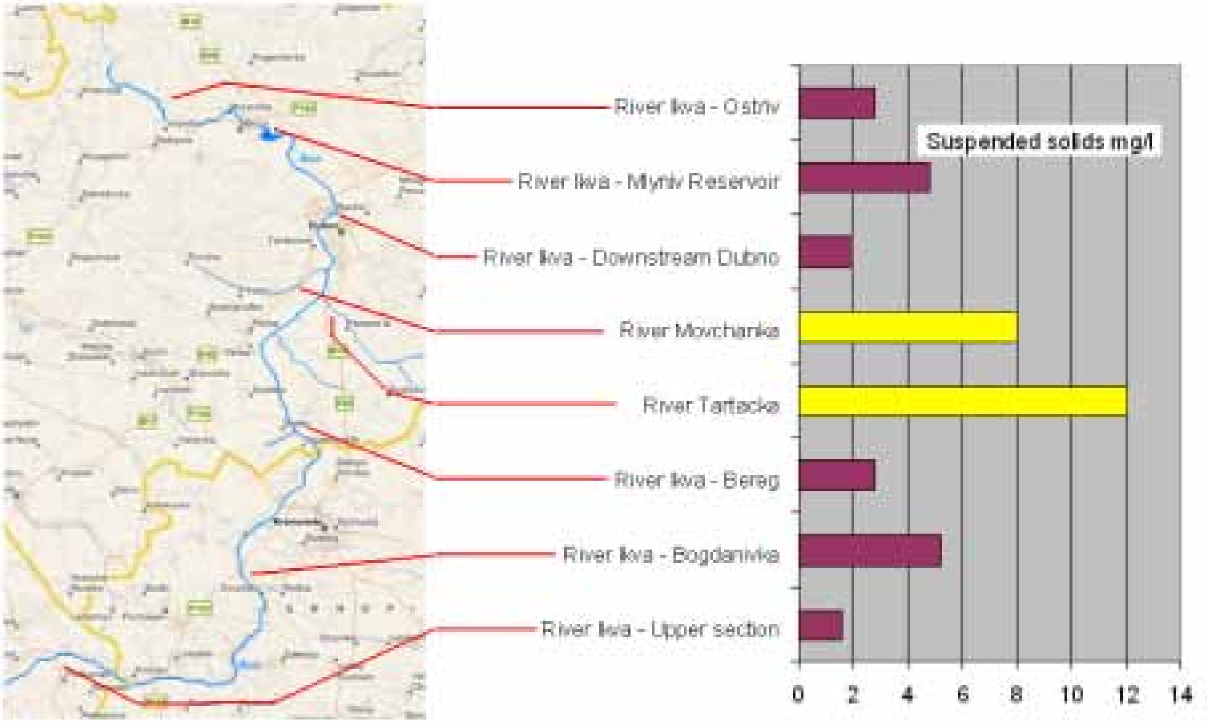

Figure 33. Concentration of suspended solids at different sites in Ikva River 15-16 June 2010

14.8 Sediment analysis in Mlyniv Reservoir

Heavy metals and recalcitrant organic pollutants have a tendency to settle out of the water phase into the sediments in lakes and reservoirs where the river water looses its speed. Some of these environmental toxins tend to accumulate in the nutrient chain ending up in highest concentrations in old carnivorous fish. Therefore it was programmed to take samples of the sediments as well as from large specimens of pike (*Esox lucius*) of Mlyniv Reservoir. The laboratory was, however, not trained in fish flesh analysis, so these had to be skipped from the monitoring. The table below (**Table 13**) shows the results from the surface sediments. The WFD has not yet given any sediment criteria; the daughter directive on prioritised compounds (DIRECTIVE 2008/105/EC) gives only criteria for the water phase. But if we compare the results in **Table 13**, with e.g. the Norwegian sediment criteria (SFT 2008) which is among the strictest in the world, the sediment in Mlyniv Reservoir falls in the best quality class for all the analysed heavy metals, i.e. close to natural background concentrations. This indicates that there are low loading of heavy metals and organic micro pollutants from activities in the catchment of Ikva River.

Table 13. Analysis of surface sediment of Mlyniv Reservoir

Collection and measurement dates		Depth, m	Point and place of collection (georeferencing)	Index			
				name	measurement unit	measurement result	normalized value MPC
1	2	3	4	5	6	7	8
		0,1	Mlynivske reservoir, (bottom sedimens)				
14.06.10				Ferrum (labile form)	mg/kg	90,559	-
14.06.10				Cadmium (labile form)	mg/ kg	0,097	-
14.06.10				Cobalt (labile form)	mg/kg	2,106	5
14.06.10				Marganese (labile form)	mg/kg	16,499	1500
14.06.10				Copper (labile form)	mg/kg	0,461	3
14.06.10				Nickel (labile form)	mg/kg	0,394	4
14.06.10				Lead (labile form)	mg/kg	5,201	6
14.06.10				Chromium (labile form)	mg/kg	10,179	6
14.06.10				Zink (labile form)	mg/kg	26,13	23

14.9 Conclusions from the monitoring

The results from the monitoring shows that Ikva River is impacted by eutrophication along the whole river stretch with concentrations of total phosphorus from 100 – 200 µg P/l, and total nitrogen of 1000 – 2000 µg N/l. The amounts of algae supported this finding and phytoplankton biomass varied from 2-6 mg/l. Downstream of the three towns Kremenetz, Dubno and Mlyniv, the river was considerably impacted by oxygen consuming organic material. This was particularly seen at the station at Bereg, downstream of the discharges of Kremenetz, where oxygen concentration was less than 4 mg O/l. At the slow flowing meandering stretch downstream of Mlyniv, the river got high biomass of algae. The Mlyniv Lake also had high amounts of phytoplankton and the high photosynthesis from the phytoplankton resulted in super saturation of oxygen. The relatively high amount of BOD indicates that it receives untreated sewage, most likely from the part of the Mlyniv population not connected to the main sewerage system.

The two tributaries had higher content of particles, as well as organic material than the main river. In Povchanka tributary a large part of the organic material was easily degradable, while the organic material in Tartaska was more recalcitrant. In the former the organics are coming from fish farming, while in the latter the organic material is remains from the peat extraction (humic type of organic material).

The monitoring confirmed the status assessment done in the characterization phase. As the lower part of the water body R2 was heavily impacted by the discharges from Kremenetz, and the WFD says that the whole water body should have the same status, it was recognized that the upper boundary of R3 should be moved upstream the discharge point from Kremenetz. However, the group meant that it was better to keep the boundary between R2 and R3 where it is to day, namely at the border between Ternopil and Rivne Oblast. This will give many practical advantages with respect to the water management, and, after the treatment facility of Kremenetz has been renovated, the impact will not be high enough to place the lower part of R2 in moderate status any longer.

The sediment analysis of Mlyniv Reservoir showed no sign of pollution from heavy metals, which indicates that there are only minor (if any?) discharges of such compound along the river, and that the diffuse pollution of such compounds are most likely also low in the area.

It has however, not been analyzed for any organic micro pollutants (which comprise the pesticides) in this project.

15. Programme of measures

15.1 Environmental goals

The general environmental goals for normal water bodies in the WFD are good ecological status (GES) and good chemical status (GCS). In heavily modified water bodies, where the modifications are regarded as essential for the life of people in the area, it is allowed to have a less strict environmental goal, called good ecological potential (GEP). In practical terms this means that we should create the best environmental situation within the constraints set by the physical alteration. But with respect to chemical pollution these water bodies should still have good chemical status as goal.

The main impacts on the water bodies of Ikva River are EUTROPHICATION and HYDRO MORPHOLOGICAL ENCROACHMENTS. From the above deductions, the goals for the water bodies of Ikva River should be as given in **Table 14**.

Table 14. Environmental goals in the different water bodies of Ikva River (GES=good ecological status, GEP=good ecological potential, GCS=good chemical status)

Code	Description	HMWB	Status	Env. goal
R1	The upper river stretch in Lviv,	No	Good	GES and GCS
R2	The upper part of the river in Ternopil.	No	Good	GES and GCS
R2.1	The lower part of the river in Ternopil	No	Moderate	GES and GCS
R3	The river stretch from Bereg to Dubno.	Yes	Moderate	GEP and GCS
T1	Tributary.	Yes	Moderate	GEP and GCS
T2	Tributary.	Yes	Moderate	GEP and GCS
T3	Tributary.	Yes	Moderate	GEP and GCS
R4	The stretch of Ikva River between Dubno and the Mlyniv Lake	No	Moderate	GES and GCS
L1	Mlyniv Lake	Yes	Moderate	GEP and GCS
R5	The stretch of Ikva River from Mlyniv and down to the confluence with Styr River	No	Good	GES and GCS

Hydro morphological encroachments and GES contra GEP

The hydro morphological encroachment has mainly been done with the aim of flood control, and with the aim of drainage of the water soaked agricultural land in the area. The polder systems (canals and gates) does not block the river completely, it is mainly done to increase the “swallowing capacity” of the river in wet periods and to constrain the flow in dry periods. These constructions are regarded as essential for a good life of the population along the river and it is not realistic policy to take it away. In this way it may qualify for being classified as HMWB with a less strict environmental goal than GES. However, the group meant that it was achievable within the constraints of the physical modifications to have GEP very close to GES.

The Dam creating Mlyniv Reservoir is, however, a complete blockage of the river, and is a migration barrier for fish and other water biota. As the river has been transformed to a lake (another category) it is clear that it is heavily modified. But the artificially imposed water level fluctuations are very small (less than one meter). Therefore, regarding the reservoir as a lake, it should be possible to achieve god ecological status here. The GEP will be more or less the same as the GES. There is no important migratory fish species present in the river, so the practical and ecological impact of the barrier effect of the dam is regarded as minor.

15.2 Operational environmental goals

This means to give concrete target values, for each water body, of the different parameters describing the environmental quality. To be able to do this properly according to the WFD, Ukraine has to develop its water type system, and a status classification system to decide the boundary values between the status classes for all the water types. The classification system should comprise water chemistry as well as the five biological quality elements (periphyton, phytoplankton, aquatic macrophytes, bottom animals, and fish).

The operative goals should be the parameter values of the boundary between class II (good ecological status) and III (moderate ecological status). We use the classification based on the risk assessment and monitoring results evaluated (partly) after the old Ukrainian water quality system as the basis for evaluating the need for abatement measures.

15.3 Pollution sources

The main pollution sources impacting the different water bodies in Ikva River is listed in **Table 15** whereas the main hydro morphological pressures are given in **Table 16**.

Table 15. Main pollution sources in Ikva River

Code	Description	HMWB	Status	Pollution sources
R1	The upper river stretch in Lviv,	No	Good	Small scale agriculture
R2	The upper part of the river in Ternopil.	No	Good	Small scale agriculture
R2.1	The lower part of the river in Ternopil	No	Moderate	Sewage from Kremenetz 50 % not connected Small scale agriculture
R3	The river stretch from Bereg to Dubno.	Yes	Moderate	Sugar factory Small scale agriculture
T1	Tributary.	Yes	Moderate	Peat extraction Small scale agriculture
T2	Tributary.	Yes	Moderate	Peat extraction Small scale agriculture
T3	Tributary.	Yes	Moderate	Fish farms Small scale agriculture
R4	The stretch of Ikva River between Dubno and the Mlyniv Lake	No	Moderate	Sewage from Dubno 40 % not connected Small scale agriculture
L1	Mlyniv Lake	Yes	Moderate	50% of Mlyniv not connected to sewerage system Small scale agriculture
R5	The stretch of Ikva River from Mlyniv and down to the confluence with Styr River	No	Good	Sewage treatment plant from Mlyniv Small scale agriculture

Table 16. Hydro morphological pressures in Ikva River

Code	Description	HMWB	Status	Hydro morphological pressures
R1	The upper river stretch in Lviv,	No	Good	No
R2	The upper part of the river in Ternopil.	No	Good	River is straitened
R2.1	The lower part of the river in Ternopil	No	Moderate	No
R3	The river stretch from Bereg to Dubno.	Yes	Moderate	Drained, straitened, dammed, sluices, split into two main arms and many canals (polder system)
T1	Tributary.	Yes	Moderate	Drained, straitened, dammed
T2	Tributary.	Yes	Moderate	Drained, straitened, dammed
T3	Tributary.	Yes	Moderate	Drained, straitened, dammed
R4	The stretch of Ikva River between Dubno and the Mlyniv Lake	No	Moderate	No
L1	Mlyniv Lake	Yes	Moderate	Dammed, but gentle water level fluctuation
R5	The stretch of Ikva River from Mlyniv and down to the confluence with Styr River	No	Good	No

15.4 Abatement measures

The goal of the WFD is to improve the water status in water bodies that are confined in moderate status or lower, as well as to prevent worsening of the water status in areas where the status are good or very good. The first of these aims needs improvement measures, whereas the second needs protective measures.

15.5 Need for abatement measures in the different water bodies of Ikva River identified during workshop no 5

Table 17 below summarizes the opinion of the September 2010 workshop in Rivne about abatement measures that need to be taken in the different water bodies of Ikva River.

Table 17. Need of measures aimed at pollution control

Code	Description	HMWB	Status	Protective measures	Improvement measures
R1	The upper river stretch in Lviv,	No	Good	Strictly use of existing legal regulations. Adjust legal system. Modernize the monitoring, tot-P, Tot-N, Chl-a, Glass fiber for suspended material anal. Riparian trees (forest), Prevent plowing to close to the river. Prevent illegal dump sites along the river. Establish recreational zones	No need
R2	The upper part of the river in Ternopil.	No	Good	The same as above	No need
R2.1	The lower part of the river in Ternopil	No	Moderate	The same as above	Modernize sewage treatment in Kremetz. Connect all houses in the town to the sewerage system. Local treatment for wastewater from scattered settlements.
R3	The river stretch from Bereg to Dubno.	Yes	Moderate	Same as above	Improve wastewater treatment in Smyga. Adjust agr. Practices, spread manure on the fields inside the growth season. Adjust the agricultural production on the basis of the balance of economical and ecological crop level.
T1	Tributary.	Yes	Moderate	Same as above	Forest planting on previous peat extraction fields.
T2	Tributary.	Yes	Moderate	Same as above	Forest planting on previous peat extraction fields.
T3	Tributary.	Yes	Moderate	Same as above	Treat fish farm runoff in artificial wetlands. Remove sediments from fish ponds. Practices, spread manure on the fields inside the growth season.
R4	The stretch of Ikva River	No	Moderate	Same as above	Improve the treatment plant from Dubno,

	between Dubno and the Mlyniv Lake				connect the remaining part of the city to the sewerage system. Increase the frequency of monitoring upstream and downstream of Dubno. Evaluate special treatment plant for the dairy that are now discharging to the municipal WWTP. Remediation of dumpsite for solid waste (overloaded-critical). Pretreatment for industrial enterprises (for Kremenetz and Mlyniv also). Improvement of wwtp for Myrogoscha agricultural college + local population. Develop rainwater collecting system.
L1	Mlyniv Reservoir	Yes	Moderate	Same as above	Connect remaining population to the treatment plant. (monitoring of wells), Dredging of sediments, Renovation of bathing places and recreation areas. Improved monitoring. Removal of aquatic vegetation., remediate dumpsite
R5	The stretch of Ikva River from Mlyniv and down to the confluence with Styr River	No	Good	Same as above	Improvement of Mlyniv WWTP

15.6 Hydro morphological measures

It was not identified any need for hydro morphological abatement measures in Ikva River, other than restoring of riparian trees here and there along the river bank. It was also discusses if it should be constructed a fish bypass canal at the Mlyniv dam, but as the river does not have any salmonids or any other important migratory fish species, it was found not necessary.

15.7 Cost – efficiency analyses of measures

The WFD requires that it should be performed a cost-benefit analysis of measures to secure that the most cost efficient measure is implemented first. It is practical to categorize the proposed measures according to the impact type. If for example River-X is impacted by eutrophication and hydro morphological encroachment it can be instructive to prioritize the measures that helps against eutrophication and those who help against the hydro morphological impacts, separately in groups of measures. For each group of proposed abatement measures the following two assessments should be done:

1. Assess the environmental improvement of the measure, and identify the indicator(s) used to assess the improvement, for example reduced concentration of algae may be a measurable indicator of measures against eutrophication.
2. Assess the cost of the measure (construction, operational and maintenance)

It is, however, very difficult to estimate and predict the environmental improvement of all kind of measures. In addition, in many cases you don’t have the virtue of legislation to implement the measure. For example the amount of fertilizer used in the agriculture is in most countries still an agrarian question and can not be regulated by the anti pollution legislation. In areas where they grow vegetables, the use of phosphorus in the chemical fertilizer is so high that it is clearly eutrophying on the recipient waters. But it is still up to the farmer how much P he will use.

The cost of the measures is also a big task to calculate, even though this is possible for all measures with more or less uncertainty.

The most practical is to calculate everything down to annual costs. For example if you are going to build a sewage treatment plant you can expect it to last in let’s say 20 years. You borrow the money with a pay back time of twenty years and e.g. interest rate of 5 %. You can then calculate the annual investment costs as annuities. But you have operational cost also, that is the salary of the personnel working there, treatment process chemicals, etc. In addition to the investment costs and operational costs you have the maintenance costs. This is, for example, if you have to repair work on the facilities.

Other measures are more annual in their nature. If you are paying compensation to a group of farmers for not allowing them to plow close to the river, or in the autumn, this is done every year, and does not need any complicated estimation for finding the annual costs.

When you have broken all measure costs down to annual costs, then you are able to compare the costs of the different measures.

And if you have been able to estimate the environmental improvement you get from the different measures, for example how much each of them will reduce the algal biomass, the cost-efficiency can be calculated as the environmental improvement per annual cost unit for each of the different measures.

15.8 Simplified cost-benefit analysis

As it is a big task to estimate both the environmental improvements and the costs of the different measures correctly, it can be very instructive to give the programme of measures a simplified cost-benefit analysis. In a such one all the proposed measures are given a score from 1-3 and a corresponding color after how they are judged to work or not work, i.e. based on your experience:

Effect (environmental improvement)

Blue - good effect 3
Yellow - moderate effect 2
Red - low or no effect 1

In the same way the measures are roughly characterized according to their cost:

Cost

Blue - low cost 3
Yellow - moderate cost 2
Red - high cost 1

The measures with blue-blue score will the ones to prioritize in the top of the measure list.

So, let us say we have an example river ,X-River, that is impacted by eutrophication and damming, we have identified three measures 1) Build new sewage treatment plant, 2) Reduce the phosphorus fertilization in the catchment, 3) Build a fish bypass ladder at the hydropower reservoir dam to allow for the sea trout and salmon to be able to pass and reach their spawning grounds. A simplified cost-benefit analysis can be set up like in **Table 18**.

Table 18. Simplified benefit-cost analysis of three proposed abatement measures in X-River

Measure	Env impr Effect	cost	Overall Score
Sewage treatment plant	3	1	3
Red. fert. agr.	3	3	9
Fish bypass	1	2	2

From this simplified analysis based on expert's general experience as well as knowledge about the river, it seems that reduced fertilization in the agriculture is the most cost efficient measure, while building a fish bypass over the dam is least cost efficient.

A third characteristic can also be given, namely if there exist any virtue of law in the legislation to implement the measure. To reduce the level of fertilization in the agriculture is an example of a measure that has good effect and is sheep, but has no virtue of law in most countries. I.e. it is difficult to implement without compensation payment to the farmers for possible reduction in harvest.

<u>Legally</u>

Blue	- Virtue of law exist (unproblematic to impose)	1
Yellow	- Virtue of law not relevant (unproblematic)	2
Red	- Virtue of law does not exist (problematic)	3

Bringing in the legal aspects should not be done before all measures have been compared in the simplified cost-benefit analysis.

15.8.1 Simplified cost-benefit analysis for the protective measures in Ikva River

At the workshop in September the following protective measures were given for all water bodies of Ikva River (see also **Table 17**):

- Strictly use of existing legal regulations.
- Adjust legal system.
- Modernize the monitoring, include parameters as tot-P, Tot-N, Chl-a, use glass fiber filter for analysis of suspended material
- Prevent cutting of all riparian trees along the river (forest),
- Prevent plowing to close to the river.
- Prevent illegal dump sites along the river.
- Establish recreational zones

It was not enough time to do anything on the Cost - Benefit analysis at the workshop, so the following treatment should be taken just as an example given by the report authors. We give the proposed measures score 1-3 for how effective we believe they are, and the same for the costs. I.e. if they are cheap they get a high score and the opposite for expensive measures. Then we rank the measures according to product of scores, see **Table 19**.

Table 19. Simplified cost benefit analysis of protective measure in Ikva River ranked after cost benefit score (ranking based on the authors subjective evaluation, view only as an example)

Measure	Effectiveness score	Cost wise score	C-B-score
Prevent illegal dump sites along the river.	3	3	9
Strictly use of existing legal regulations.	3	3	9
Modernize the monitoring	3	2	6
Prevent cutting of all riparian trees	2	3	6
Prevent plowing to close to the river.	3	2	6
Adjust legal system.	2	2	4
Establish recreational zones	2	2	4

There are two blue-blue measures, which both are cheap and are believed to have good effect, namely to prevent illegal dump sites along the river, as well as sharpen the use of existing legislation and regulation rules.

If we look at the proposed abatement measures in the water body (R4) downstream of Dubno (see **Table 17**), and gives them the same type of scores for effectiveness and for cost, and sort the table according to cost-benefit score, the prioritized list of measures are given in **Table 20**. There were identified three measures that are believed to have good effect, namely 1) improve the sewage treatment plant of Dubno, 2) connect the remaining part of the city to the sewerage system, 3) Remediation of the dumpsite for solid waste. They are all three judged to be medium costly, and get the cost wise score of 2. Again this has not been subject to any discussion in the Ikva group in any workshops yet and is just shown as an example.

Table 20. Simplified cost benefit analysis for the water body (R4) downstream of Dubno in Ikva River, prioritized after C/B-score (column to the right). Ranking is done after the author's subjective evaluation, and should be viewed as an example only.

Measure	**Effectiveness score**	**Cost wise score**	**C/B-score**
Improve the treatment plant in Dubno	3	2	6
Connect the remaining part of the city to the sewerage system.	3	2	6
Remediation of dumpsite for solid waste (overloaded-critical).	3	2	6
Evaluate special treatment plant for the dairy that are now discharging to the municipal WWTP.	2	2	4
Pretreatment for industrial enterprises (for Kremenetz and Mlyniv also).	2	2	4
Increase the frequency of monitoring upstream and downstream of Dubno.	1	3	3
Improvement of wwtp for Myrogoscha agricultural college + local population.	2	1	2
Develop rainwater collecting system.	2	1	2

In the same way the proposed measures for the other water bodies could have been evaluated and ranked. If you bring together experienced people in this process the ranking will most likely be about the same as it would have been if the laborious process of full cost – benefit analysis has been carried out. We have now identified the most important measures. But before you start to implement them, you need to estimate their costs also as a basis for getting them passed the political councils that allocate the necessary money.

15.8.2 Unproportionally high costs – Exemptions

In a few cases, even if the water body in question is not heavily modified, the human activity in the catchment may be so large that it is impossible to reach good ecological status without drastic measures as e.g. move and resettlement of people, close down of to much agriculture, etc. For such cases it is said that to reach good ecological status has unproportionally high costs.

For such cases the member state can apply for exemption (see WFD article 4.4 and 4.5), extension of the dead line and/or to set a less strict environmental goal than good ecological status. Water bodies in some intensively run animal husbandry areas in Holland, and perhaps Denmark, are areas that may need such exemptions. But in the catchment of Ikva River, exemptions are not needed.

16. Water Management Plan

For each River Basin District that lies totally within a country, or the national part of an international River Basin District, it should be elaborated a water management plan, after a certain recipe, that shall be reported to the European Commission. The first version of this plan should be ready 9 years after the directive has entered into force in a country, and it should be rolled over every 6th year thereafter. I.e. such a plan should be made for the Pripyat Water Region of Ukraine, headed by Dept. Env. Prot. Rivne. The plan should be compiled of the sub-plans made in the 5 different Water Areas, see chapter 3. In these Water Areas there are often made a water management plan for each river. Ikva River is such a river in the Rivne Water Area.

So what we have been working with so far is a water management plan for Ikva River. The sub-plans from water areas are aggregated up to the management plan for the whole Water Region. The sub plans are not formal documents required by the EU, and they have a more narrow content than the full water management plan for the water region.

The content of a full River Basin District Water Management Plan, i.e. the plan that shall be produced for the Pripyat Water Region of Ukraine, is given in the list below:

Content for a full River Basin District Water Management Plan

1. Introduction
2. Information about the river basin authority (= water region authority) and how they organise the work within the water region
3. Description of the water region, the partition into water areas, and the water bodies
4. Description of the environmental pressures and which environmental problems they cause in the different water areas
5. Register over protected areas
6. Environmental goals
7. A summary of the economical analyses of water use
8. A summary of the programme of measures
    a. a description of which sector authorities that have the responsibility for carrying out the different measures
    b. Need for law-adjustments and new regulations
    c. Description of performed and ongoing measures
    d. Prioritised measures in the different water areas in the plan period
    e. Estimated costs of measures
9. A description of cultural heritage sites, in, and along the water bodies that has relevance for the water management plans
10. A register of any relevant management plans and development plans in the different water areas constituting the water region
11. A summary of the public participation (consultation, hearings, meetings) in the development of the water management plan
12. A list of the competent authorities involved in water management, both in the water areas and the water region
13. Overview of, and references to, the background material that has been used to build up the water management plan
14. Explanations of special words and expressions

In the Ikva sub-plan we have not work with the legal aspects, and not to any extent on the economic analyses of water use, or cost estimates of measures, or cultural heritage sites, or protected areas. We have been most occupied with identifying the water bodies, assessing the status and environmental goals, and identify the abatement measures needed to bring the water bodies back to good ecological status. These are normal procedures for single river management plans or sub-areas water management plans. The legal items have a wider scope and need often to be solved on the national level.

17. Appendix - Primary data

17.1 General measures to improve the waters of Ukraine was given as a written contribution of the Ukrainian group:

Improvement of the Ikva water quality requires development and implementation of the system of environment and water protection activities. The specific water protection activities for the small river basins are divided into preventive, distributive and mitigation measures.
Preventive measures are the most important in terms of environment protection. They are directed at elimination of direct causes and sources of pollution. It should be stressed that the preventive activities provide the foundation for the system of measures directed at securing high quality natural water.
Distributive protection measures regulate the anthropogenic pressure on the river basin using the assimilation capacities of different segments of the catchment basin.
Mitigation measures are the last segment in the system of water protection measures, which ensure neutralization of hazardous impact on the river water quality.
Due to the unsatisfactory water quality in the Ikva, apart from the measures specified above, the following activities are required:

- speed up the development of a modern legal framework and its enforceability with regard to the water protection activities within the river basin;
- introduce water use charges and ensure that the breach of the water use rules would be economically disadvantageous;
- improve the techniques for control and assessment of conditions of water bodies and anthropogenic pressure;
- expand the conservation areas, implement the practice of identification of "safety islands" on each field, each segment of a forest or river
- avoid the discharge of untreated or insufficiently treated wastewaters into the river that can be achieved by enhancement or reconstruction of treatment facilities;
- reduce devastation and increase forestation within the river basin in order to enhance the river self-cleaning capacities;
- develop a long-term program for improvement of the river water quality.

Table 21. Main hydro chemical, hydro biological, and toxically characteristics of water quality in the river Ikva.

No	Characteristics of water quality	Units	River Ikva		
			Beginning	Middle stream	Canal
1	Mineralization	mg/l	405	478	437
2	HCO_3^-	mg/l	-	-	-
3	SO_4^{2-}	mg/l	34,8	35,6	31,7
4	Cl^-	mg/l	12,9	13,5	13,7
5	Mg^{2+}	mg/l	12,1	13,2	12,3
6	Suspended substances	mg/l	13,9	86,9	8,92
7	NH_4^+	mg/l	0,41	0,16	0,22
8	NO_2^-	mg/l	0,001	0,017	0,018
9	NO_3^-	mg/l	0,21	0,68	0,59

10	Total Fe	mg/l	0,33	0,3	0,16
11	Coli- index	mln.kl/ l	-	39,5	2,5
12	Phosphorus general	mg/l	0,06	0,06	0,06
13	BOD5	mg O_2/ l	4,04	4,03	3,0
14	Bi-chromium oxidation	mg O/ l	8,4	7,5	5,7
15	Permanganate for oxidation	mg O/l	23,2	24,3	24,5
16	Soluble oxygen	mg/l	9,2	10,0	8,7
17	pH		7,2	8,02	8,1
18	Cu	mg/l	0,002	0,003	0,008
19	Zn	mg/l	0,01	0,008	0,033
20	Ni	mg/l	n/a	n/a	n/a
21	Co	mg/l	n/a	0,004	0,022
22	Mn	mg/l	0,048	0,013	0,039
23	Pb	mg/l	0,002	0,033	0,048
24	Cr	mg/l	n/a	0,001	n/a
25	β-active	mg/l	n/a	n/a	$3,1*10^{-10}$
26	Cs^{134} + Cs^{137}	mg/l	n/a	n/a	$2,8*10^{-11}$
27	Sr^{90}	mg/l	n/a	n/a	$3,1*10^{-11}$
28	oil substances	mg/l	n/a	n/a	0,01
29	Phenol	mg/l	n/a	n/a	n/a
30	СПАР	mg/l	0,01	0,04	0,04
31	Chlorine organic pesticides	mg/l	0,016	0,01	0,037
32	Phosphorus organic pesticides	mg/l	0,005	0,001	n/a
33	Microorganisms	mln.kl/ml	5,0	5,5	4,0
34	Zooplankton	thou items/$м^3$	380	500	1070
35	Zooplankton	mg/$м^3$	10,7	27,5	16,1
36	Macrophites (projected coverage)	%	7,0	5,0	12,0
37	Organic philtrators	items/$м^2$	1000	800	2000
38	Index of sanitary tests on phytoplankton Pantle and Buka		2,2	2,0	2,1
39	San. testing		β-мезосапр.	β-мезосапр.	β-мезосапр.
40	Output		1,9	2,0	1,92
41	Destruction		2,25	1,89	1,71
42	Index of selfcleaning		0,73	1,1	1,41
43	Environmental condition		balance	balance	balance

Table 22. Numbers on base concentrations of pollutants in the river Ikva

Parameter	Calculated base , mg/l
BOD	5,8
Suspended substances	5,2
Sulphates	42
Chlorides	25
Oil substances	0
Fe	0,21
Nitrogen ammonium	0,5
Nitrites	0,01
Nitrates	4
Calcium	112
Magnesium	6,08

17.2 Recommendations on the water protection activities aimed at improvement of the river water quality

Improvement of the Ikva water quality requires development and implementation of the system of environment and water protection activities. The specific water protection activities for the small river basins are divided into preventive, distributive and mitigation measures.
Preventive measures are the most important in terms of environment protection. They are directed at elimination of direct causes and sources of pollution. It should be stressed that the preventive activities provide the foundation for the system of measures directed at securing high quality natural water.
Distributive protection measures regulate the anthropogenic pressure on the river basin using the assymilation capacities of different segments of the catchment basin.
Mitigation measures are the last segment in the system of water protection measures, which ensure neutralization of hazardous impact on the river water quality.
Due to the unsatisfactory water quality in the Ikva, apart from the measures specified above, the following activities are required:

- speed up the development of a modern legal framework and its enforceability with regard to the water protection activities within the river basin;
- introduce water use charges and ensure that the breach of the water use rules would be economically disadvantageous;
- improve the techniques for control and assessment of conditions of water bodies and anthropogenic pressure;
- expand the conservation areas, implement the practice of identification of "safety islands" on each field, each segment of a forest or river
- avoid the discharge of untreated or insufficiently treated wastewaters into the river that can be achieved by enhancement or reconstruction of treatment facilities;
- reduce devastation and increase forestation within the river basin in order to enhance the river self-cleaning capacities;
- develop a long-term program for improvement of the river water quality.

Table 23. Data from the monitoring mission 15-16 June 2010 in Ikva River, Lukashi Village, Lviv Region

Collection and measurement dates	Sample number		Point and place of collection (georeferencing)	Index									Data on PM	
	under collection certificate	registration		name	measurement unit	measurement result	normalized value						reference number	measurement error, δ %, (Δ), $P=0,95$*
							LAC			$C_Д$	$C_Н$			
							under 4.1.1	under 4.1.2	under 4.1.3	under 4.2.1	under 4.2.2			
1	2	3	4	5	6	7	8	9	10	11	12		13	14
15.06.10 / 15.06.10	1	151/10	Ikva River, within Lukashi Village, Lviv Region	Ammonium ion	mg/dm³	0,25	2,6						МВВ 081/12-0106-03	±25%
				BOD_5	mgO2/dm³	2,18	6						КНД 211.1.4.024-95	<3 (2,18)
				Water index	unit pH	8,01	6,5-8,5						МВВ 081/12-0317-06	±(0,1)
				Hardness	mg/dm³	101,67							[2], c.297	>10 (101,67)
				Suspended substances	mg/dm³	1,6	□0,75 до фону						КНД 211.1.4.039-95	<5 (1,6)
				Odour	point	0							[3], c.21	
				Calcium	mg/dm³	79,96							МВВ 081/12-0006-01	±(10-5)%
				Dissolved oxygen	mg/dm³	7,76	□4						МВВ 081/12-0008-01	±10%
				Magnesium	mg/dm³	21,71							МВВ 081/12-0006-01	±5%
				Oil product and (carbohydrate non-polar)	mg/dm³	0,029	0,3						МВВ 99-12-98	±(65-25)%
				Nitrate ions	mg/dm³	3,7	45						КНД 211.1.4.027-95	±40,3%
				Nitrite ions	mg/dm³	0,08	3,3						КНД 211.1.4.023-95	±(0,03)
				Sulphates	mg/dm³	33,332	500						МВВ 081/12-0007-01	<50 (33,332)
				Dry residue	mg/dm³	336	1000						МВВ № 081/12-0109-03	±5%
				Phosphates	mg/dm³	0,11	3,5						МВВ 081/12-0005-01	±(15-10)%
				Fluorides	mg/dm³	0							[2], c.1072	<0,1 (0)
				COD	mgO/dm³	34,7	30						КНД 211.1.4.021-95	±(5,2)
				Chloride ions	mg/dm³	7,8	350						МВВ 081/12-0004-01	<10 (7,8)
				Ferrum	mg/dm³	0,134	0,3						МВВ 081/12-0415-07	±24%
				Cadmium	mg/dm³	0	0,001						[6], c.57	<0,05 (0)
				Manganese	mg/dm³	0,038	0,1						МВВ 081/12-0416-07	±23%
				Copper	mg/dm³	0,036	1						КНД 211.1.4.032-95	<0,1 (0,036)
				Nickel	mg/dm³	0	0,1						[6], c.94	<0,3 (0)
				Lead	mg/dm³	0	0,1						[6], c.94	<0,3 (0)
				Chrome (gen.)	mg/dm³	0	0,03						МВВ 081/12-0414-07	<0,1 (0)
				Zink	mg/dm³	0							[6], c.118	<0,5 (0)

Table 24. Data from the monitoring mission in Ikva River 15-16 June 2010, Ikva River within Bogdanivka Village

Collection and measurement dates	Sample number		Point and place of collection (georeferencing)	Index								Data on PM	
	under collection certificate	registration		name	measurement unit	measurement result	normalized value					reference number	measurement error, δ %, (Δ), P=0,95*
							LAC			$C_Д$	C_H		
							under 4.1.1	under 4.1.2	under 4.1.3	under 4.2.1	under 4.2.2		
1	2	3	4	5	6	7	8	9	10	11	12	13	14
15.06.10 / 15.06.10	1	152/10	Ikva River, within BogdanivkaVillage	Ammonium ion	mg/dm³	0,48	2,6					МВВ 081/12-0106-03	±25%
				BOD_5	mgO2/dm³	2,63	6					КНД 211.1.4.024-95	<3 (2,63)
				Water index	unit pH	7,97	6,5-8,5					МВВ 081/12-0317-06	±(0,1)
				Hardness	mg/dm³	91,36						[2], c.297	
				Suspended substances	mg/dm³	5,2	□0,75 до фону					КНД 211.1.4.039-95	±20,0%
				Odour	point	0						[3], c.21	
				Calcium	mg/dm³	50,5						МВВ 081/12-0006-01	±(10-5)%
				Dissolved oxygen	mg/dm³	8,22	□4					МВВ 081/12-0008-01	±10%
				Magnesium	mg/dm³	40,86						МВВ 081/12-0006-01	±5%
				Oil product and (carbohydrate non-polar)	mg/dm³	0,04	0,3					МВВ 99-12-98	±(65-25)%
				Nitrate ions	mg/dm³	4,8	45					КНД 211.1.4.027-95	±37,6%
				Nitrite ions	mg/dm³	0	3,3					КНД 211.1.4.023-95	<0,03 (0)
				Sulphates	mg/dm³	35,183	500					МВВ 081/12-0007-01	<50 (35,183)
				Dry residue	mg/dm³	347	1000					МВВ № 081/12-0109-03	±5%
				Phosphates	mg/dm³	0,18	3,5					МВВ 081/12-0005-01	±(15-10)%
				Fluorides	mg/dm³	0,1						[2], c.1072	±(40-21)%
				COD	mgO/dm³	35,1	30					КНД 211.1.4.021-95	±(5,2)
				Chloride ions	mg/dm³	9,218	350					МВВ 081/12-0004-01	<10 (9,218)
				Ferrum	mg/dm³	0,109	0,3					МВВ 081/12-0415-07	±24%
				Cadmium	mg/dm³	0	0,001					[6], c.57	<0,05 (0)
				Marganese	mg/dm³	0,036	0,1					МВВ 081/12-0416-07	±23%
				Copper	mg/dm³	0,037	1					КНД 211.1.4.032-95	<0,1 (0,037)
				Nickel	mg/dm³	0	0,1					[6], c.94	<0,3 (0)
				Lead	mg/dm³	0	0,03					МВВ 081/12-0414-07	<0,1 (0)
				Chrome (gen.)	mg/dm³	0						[6], c.118	<0,5 (0)
				Zink	mg/dm³	0,02	1					МВВ 081/12-0413-07	±22%

Table 25. Data from the monitoring mission 15-16 June 2010, Ikva River within the Bereg Village

Collection and measurement dates	Sample number		Point and place of collection (georeferencing)	Index								Data on PM	
	under collection certificate	registration		name	measurement unit	measurement result	normalized value: LAC under 4.1.1	LAC under 4.1.2	under 4.1.3	$C_Д$ under 4.2.1	C_H under 4.2.2	reference number	measurement error, δ %, (Δ), $P=0,95$*
1	2	3	4	5	6	7	8	9	10	11	12	13	14
15.06.10 / 15.06.10	1	153/10	Ikva River, within Bereg Village	Ammonium ion	mg/dm³	1,55	2,6					МВВ 081/12-0106-03	±10%
				BOD_5	mgO2/dm³	3,84	6					КНД 211.1.4.024-95	±(7,)
				Water index	unit pH	7,95	6,5-8,5					МВВ 081/12-0317-06	±(0,1)
				Hardness	mg/dm³	238,12						[2], c.297	
				Suspended substances	mg/dm³	2,8	□0,75 до фону					КНД 211.1.4.039-95	<5 (2,8)
				Odour	point	0						[3], c.21	
				Calcium	mg/dm³	206,2						МВВ 081/12-0006-01	>150 (206,2)
				Dissolved oxygen	mg/dm³	3,87	□4					МВВ 081/12-0008-01	±10%
				Magnesium	mg/dm³	31,92						МВВ 081/12-0006-01	±5%
				Oil product and (carbohydrate non-polar)	mg/dm³	4	45					КНД 211.1.4.027-95	±39,5%
				Nitrate ions	mg/dm³	33,949	500					МВВ 081/12-0007-01	<50 (33,949)
				Nitrite ions	mg/dm³	1,11	3,3					КНД 211.1.4.023-95	±(0,24)
				Sulphates	mg/dm³	339	1000					МВВ № 081/12-0109-03	±5%
				Dry residue	mg/dm³	0,03	0,3					МВВ 99-12-98	±(65-25)%
				Phosphates	mg/dm³	0,82	3,5					МВВ 081/12-0005-01	±(15-10)%
				Fluorides	mg/dm³	0,054						[2], c.1072	<0,1 (0,054)
				COD	mgO/dm³	45,4	30					КНД 211.1.4.021-95	±(6,8)
				Chloride ions	mg/dm³	13,47	350					МВВ 081/12-0004-01	±10%
				Ferrum	mg/dm³	0,209	0,3					МВВ 081/12-0415-07	±24%
				Cadmium	mg/dm³	0	0,001					[6], c.57	<0,05 (0)
				Manganese	mg/dm³	0,079	0,1					МВВ 081/12-0416-07	±23%
				Copper	mg/dm³	0,062	1					КНД 211.1.4.032-95	<0,1 (0,062)
				Nickel	mg/dm³	0	0,1					[6], c.94	<0,3 (0)
				Lead	mg/dm³	0	0,03					МВВ 081/12-0414-07	<0,1 (0)
				Chrome (gen.)	mg/dm³	0						[6], c.118	<0,5 (0)
				Zink	mg/dm³	0,01	1					МВВ 081/12-0413-07	±22%

Table 26. Data from the monitoring mission 15-16 June, the tributary Tartatska River, Dubno Region

Collection and measurement dates	Sample number		Point and place of collection (georeferencing)	Index									Data on PM	
	under collection certificate	registration		name	measurement unit	measurement result	normalized value						reference number	measurement error, δ %, (Δ), P=0,95*
							LAC			$C_Л$	C_H			
							under 4.1.1	under 4.1.2	under 4.1.3	under 4.2.1	under 4.2.2			
1	2	3	4	5	6	7	8	9	10	11	12		13	14
15.06.10 / 15.06.10	1	154/10	Tartatska River, Dubno Region	Ammonium ion	mg/dm³	0,21		0,5					МВВ 081/12-0106-03	±25%
				BOD_5	mgO2/dm³	4		3					КНД 211.1.4.024-95	±(7,)
				Water index	unit pH	8,04		6,5-8,5					МВВ 081/12-0317-06	±(0,1)
				Hardness	mg/dm³	217,78							[2], c.297	
				Suspended substances	mg/dm³	12		□0,25 to background					КНД 211.1.4.039-95	±20,0%
				Odour	point	0							[3], c.21	
				Calcium	mg/dm³	199,9		180					МВВ 081/12-0006-01	>150 (199,9)
				Dissolved oxygen	mg/dm³	7,33		□6					МВВ 081/12-0008-01	±10%
				Magnesium	mg/dm³	17,88		40					МВВ 081/12-0006-01	±5%
				Oil product and (carbohydrate non-polar)	mg/dm³	0,015		0,05					МВВ 99-12-98	±(65-25)%
				Nitrate ions	mg/dm³	4,9		40					КНД 211.1.4.027-95	±37,3%
				Nitrite ions	mg/dm³	0,08		0,08					КНД 211.1.4.023-95	±(0,03)
				Sulphates	mg/dm³	32,92		100					МВВ 081/12-0007-01	<50 (32,92)
				Dry residue	mg/dm³	358							МВВ № 081/12-0109-03	±5%
				Phosphates	mg/dm³	0,1		0,17					МВВ 081/12-0005-01	±(15-10)%
				Fluorides	mg/dm³	0,022		0,75					[2], c.1072	<0,1 (0,022)
				COD	mgO/dm³	37,2							КНД 211.1.4.021-95	±(5,5)
				Chloride ions	mg/dm³	6,382		300					МВВ 081/12-0004-01	<10 (6,382)
				Ferrum	mg/dm³	0,28		0,1					МВВ 081/12-0415-07	±24%
				Cadmium	mg/dm³	0		0,005					[6], c.57	<0,05 (0)
				Marganese	mg/dm³	0,028		0,01					МВВ 081/12-0416-07	±23%
				Copper	mg/dm³	0,032		□0,001 to background					КНД 211.1.4.032-95	<0,1 (0,032)
				Nickel	mg/dm³	0		0,01					[6], c.94	<0,3 (0)
				Lead	mg/dm³	0		0,1					МВВ 081/12-0414-07	<0,1 (0)
				Chrome (gen.)	mg/dm³	0							[6], c.118	<0,5 (0)
				Zink	mg/dm³	0,009		0,01					МВВ 081/12-0413-07	±22%

Table 27. Data from the monitoring mission 15-16 June 2010, Povchanka Tributary, Turkiv Village.

Collection and measurement dates	Sample number		Point and place of collection (georeferencing)	Index								Data on PM	
	under collection certificate	registration		name	measurement unit	measurement result	normalized value					reference number	measurement error, δ %, (Δ), $P=0,95$*
							LAC			$C_Д$	C_H		
							under 4.1.1	under 4.1.2	under 4.1.3	under 4.2.1	under 4.2.2		
1	2	3	4	5	6	7	8	9	10	11	12	13	14
15.06.10 / 15.06.10	1	155/10	Povchanka River, Turkiv Village	Ammonium ion	mg/dm³	0,21	2,6					МВВ 081/12-0106-03	±25%
				BOD$_5$	mgO2/dm³	7,82	6					КНД 211.1.4.024-95	±(7,)
				Water index	unit pH	8,2	6,5-8,5					МВВ 081/12-0317-06	±(0,1)
				Hardness	mg/dm³	64,42						[2], c.297	
				Suspended substances	mg/dm³	8	□0,75 to background					КНД 211.1.4.039-95	±20,0%
				Odour	point	0						[3], c.21	
				Calcium	mg/dm³	42,08						МВВ 081/12-0006-01	±(10-5)%
				Dissolved oxygen	mg/dm³	10,6	□4					МВВ 081/12-0008-01	±10%
				Magnesium	mg/dm³	22,34						МВВ 081/12-0006-01	±5%
				Oil product and (carbohydrate non-polar)	mg/dm³	0,035	0,3					МВВ 99-12-98	±(65-25)%
				Nitrate ions	mg/dm³	9,9	45					КНД 211.1.4.027-95	±25,2%
				Nitrite ions	mg/dm³	0,14	3,3					КНД 211.1.4.023-95	±(0,05)
				Sulphates	mg/dm³	28,599	500					МВВ 081/12-0007-01	<50 (28,599)
				Dry residue	mg/dm³	361	1000					МВВ № 081/12-0109-03	±5%
				Phosphates	mg/dm³	0,19	3,5					МВВ 081/12-0005-01	±(15-10)%
				Fluorides	mg/dm³	0,086						[2], c.1072	<0,1 (0,086)
				COD	mgO/dm³	45,1	30					КНД 211.1.4.021-95	±(6,7)
				Chloride ions	mg/dm³	12,054	350					МВВ 081/12-0004-01	±10%
				Ferrum	mg/dm³	0,103	0,3					МВВ 081/12-0415-07	±24%
				Cadmium	mg/dm³	0	0,001					[6], c.57	<0,05 (0)
				Manganese	mg/dm³	0,034	0,1					МВВ 081/12-0416-07	±23%
				Copper	mg/dm³	0,033	1					КНД 211.1.4.032-95	<0,1 (0,033)
				Nickel	mg/dm³	0	0,1					[6], c.94	<0,3 (0)
				Lead	mg/dm³	0	0,03					МВВ 081/12-0414-07	<0,1 (0)
				Chrome (gen.)	mg/dm³	0						[6], c.118	<0,5 (0)
				Zink	mg/dm³	0,008	1					МВВ 081/12-0413-07	±22%

Table 28. Data from the monitoring mission 15-16 June 2010, Ikva River below Dubno Town, Ivanny Village

Collection and measurement dates	Sample number		Point and place of collection (georeferencing)	Index								Data on PM	
	under collection certificate	registration		name	measurement unit	measurement result	normalized value					reference number	measurement error, δ %, (Δ), $P=0,95$*
							LAC			C_{II}	C_{H}		
							under 4.1.1	under 4.1.2	under 4.1.3	under 4.2.1	under 4.2.2		
1	2	3	4	5	6	7	8	9	10	11	12	13	14
14.06.10 / 14.06.10	1	142/10	Ikva River, below Dubno Town, Ivannye Village	Ammonium ion	mg/dm³	0,75	2,6					PM 081/12-0106-03	±10%
				BOD_5	mgO2/dm³	2,72	6					KND 211.1.4.024-95	<3 (2,72)
				Water index	unit pH	8,04	6,5-8,5					PM 081/12-0317-06	±(0,1)
				Hardness	mg/dm³	249,67						[2], p.297	
				Suspended substances	mg/dm³	2	□0,75 to background					KND 211.1.4.039-95	<5 (2)
				Odour	point	0						[3], p.21	
				Calcium	mg/dm³	220,94						PM 081/12-0006-01	
				Dissolved oxygen	mg/dm³	4,92	□4					PM 081/12-0008-01	±10%
				Magnesium	mg/dm³	28,73						PM 081/12-0006-01	±5%
				Oil product and (carbohydrate non-polar)	mg/dm³	0,025	0,3					PM 99-12-98	±(65-25)%
				Nitrate ions	mg/dm³	5,5	45					KND 211.1.4.027-95	±35,9%
				Nitrite ions	mg/dm³	0,32	3,3					KND 211.1.4.023-95	±(0,09)
				Sulphates	mg/dm³	37,035	500					PM 081/12-0007-01	<50 (37,035)
				Dry residue	mg/dm³	435	1000					PM No. 081/12-0109-03	±5%
				Phosphates	mg/dm³	0,43	3,5					PM 081/12-0005-01	±(15-10)%
				Fluorides	mg/dm³	0,022						[2], p.1072	<0,1 (0,022)
				COD	mgO/dm³	48,6	30					KND 211.1.4.021-95	±(7,3)
				Chloride ions	mg/dm³	17,73	350					PM 081/12-0004-01	±10%
				Ferrum	mg/dm³	0,091	0,3					PM 081/12-0175-05	±20%
				Cadmium	mg/dm³	0	0,001					[6], p.57	<0,05 (0)
				Marganese	mg/dm³	0,022	0,1					PM 081/12-0416-07	±23%
				Copper	mg/dm³	0,002	1					KND 211.1.4.032-95	<0,1 (0,002)
				Nickel	mg/dm³	0	0,1					[6], p.94	<0,3 (0)
				Lead	mg/dm³	0	0,03					PM 081/12-0414-07	<0,1 (0)
				Chrome (gen.)	mg/dm³	0						[6], p.118	<0,5 (0)
				Zink	mg/dm³	0,06	1					PM 081/12-0413-07	±22%

Table 29. Data from the monitoring mission 15-16 June 2010, Mlynivske Reservoir, Mlyniv Town

Collection and measurement dates	Sample number		Point and place of collection (georeferencing)	Index								Data on PM	
	under collection certificate	registration		name	measurement unit	measurement result	normalized value					reference number	measurement error, δ %, (Δ), $P=0,95$*
							MPC			$C_Д$	$C_П$		
							under 4.1.1	under 4.1.2	under 4.1.3	under 4.2.1	under 4.2.2		
1	2	3	4	5	6	7	8	9	10	11	12	13	14
14.06.10 / 14.06.10	1	141/10	Mlynivske reservoir, urban-type village Mlyniv	Ammonium ion	mg/dm³	0,37		0,5				МВВ 081/12-0106-03	±25%
				BOD_5	mgO2/dm³	5,88		3				КНД 211.1.4.024-95	±(7,)
				Water index	unit pH	8,26		6,5-8,5				МВВ 081/12-0317-06	±(0,1)
				Hardness	mg/dm³	217,09						[2], c.297	>10 (217,09)
				Suspended substances	mg/dm³	4,8		□0,25 до фону				КНД 211.1.4.039-95	<5 (4,8)
				Odour	point	0						[3], c.21	
				Calcium	mg/dm³	185,17		180				МВВ 081/12-0006-01	>150 (185,17)
				Dissolved oxygen	mg/dm³	10,27		□6				МВВ 081/12-0008-01	±10%
				Magnesium	mg/dm³	31,92		40				МВВ 081/12-0006-01	±5%
				Oil product and (carbohydrate non-polar)	mg/dm³	0		40				КНД 211.1.4.027-95	<0,5 (0)
				Nitrate ions	mg/dm³	32,509		100				МВВ 081/12-0007-01	<50 (32,509)
				Nitrite ions	mg/dm³	0,12		0,08				КНД 211.1.4.023-95	±(0,05)
				Sulphates	mg/dm³	351						МВВ № 081/12-0109-03	±5%
				Dry residue	mg/dm³	0,15		0,17				МВВ 081/12-0005-01	±(15-10)%
				Phosphates	mg/dm³	0,097		0,75				[2], c.1072	<0,1 (0,097)
				Fluorides	mg/dm³	0,015		0,05				МВВ 99-12-98	±(65-25)%
				COD	mgO/dm³	35,2						КНД 211.1.4.021-95	±(5,2)
				Chloride ions	mg/dm³	14,89		300				МВВ 081/12-0004-01	±10%
				Ferrum	mg/dm³	0,022		0,1				МВВ 081/12-0415-07	±24%
				Cadmium	mg/dm³	0		0,005				[6], c.57	<0,05 (0)
				Manganese	mg/dm³	0,02		0,01				МВВ 081/12-0416-07	±23%
				Copper	mg/dm³	0,058		□0,001 до фону				КНД 211.1.4.032-95	<0,1 (0,058)
				Nickel	mg/dm³	0		0,01				[6], c.94	<0,3 (0)
				Lead	mg/dm³	0		0,1				МВВ 081/12-0414-07	<0,1 (0)
				Chrome (gen.)	mg/dm³	0						[6], c.118	<0,5 (0)
				Zink	mg/dm³	0,011		0,01				МВВ 081/12-0413-07	±22%

Table 30. Data from the monitoring mission 15-16 June 2010, Ikva River within Ostriv Village

Collection and measurement dates	Sample number		Point and place of collection (georeferencing)	Index								Data on PM	
	under collection certificate	registration		name	measurement unit	measurement result	normalized value					reference number	measurement error, δ %, (Δ), P=0,95*
							LAC			$C_Д$	$C_Н$		
							under 4.1.1	under 4.1.2	under 4.1.3	under 4.2.1	under 4.2.2		
1	2	3	4	5	6	7	8	9	10	11	12	13	14
14.06.10 / 14.06.10	1	143/10	Ikva River, within Ostriv Village	Ammonium ion	mg/dm³	0,56	2,6					МВВ 081/12-0106-03	±10%
				BOD$_5$	mgO2/dm³	2,42	6					КНД 211.1.4.024-95	<3 (2,42)
				Water index	unit pH	8,05	6,5-8,5					МВВ 081/12-0317-06	±(0,1)
				Hardness	mg/dm³	216,27						[2], c.297	>10 (216,27)
				Suspended substances	mg/dm³	2,8	□0,75 to background					КНД 211.1.4.039-95	<5 (2,8)
				Odour	point	0						[3], c.21	
				Calcium	mg/dm³	183,07						МВВ 081/12-0006-01	
				Dissolved oxygen	mg/dm³	6,58	□4					МВВ 081/12-0008-01	±10%
				Magnesium	mg/dm³	33,2						МВВ 081/12-0006-01	
				Oil product and (carbohydrate non-polar)	mg/dm³	0,035	0,3					МВВ 99-12-98	±(65-25)%
				Nitrate ions	mg/dm³	0,9	45					КНД 211.1.4.027-95	±47,0%
				Nitrite ions	mg/dm³	0,38	3,3					КНД 211.1.4.023-95	±(0,10)
				Sulphates	mg/dm³	35,595	500					МВВ 081/12-0007-01	<50 (35,595)
				Dry residue	mg/dm³	378	1000					МВВ № 081/12-0109-03	±5%
				Phosphates	mg/dm³	0,46	3,5					МВВ 081/12-0005-01	±(15-10)%
				Fluorides	mg/dm³	0,2						[2], c.1072	±(40-21)%
				COD	mgO/dm³	47,9	30					КНД 211.1.4.021-95	±(7,2)
				Chloride ions	mg/dm³	13,47	350					МВВ 081/12-0004-01	±10%
				Ferrum	mg/dm³	0,067	0,3					МВВ 081/12-0415-07	±24%
				Cadmium	mg/dm³	0	0,001					[6], c.57	<0,05 (0)
				Manganese	mg/dm³	0,028	0,1					МВВ 081/12-0416-07	±23%
				Copper	mg/dm³	0,008	1					КНД 211.1.4.032-95	<0,1 (0,008)
				Nickel	mg/dm³	0	0,1					[6], c.94	<0,3 (0)
				Lead	mg/dm³	0	0,03					МВВ 081/12-0414-07	<0,1 (0)
				Chrome (gen.)	mg/dm³	0						[6], c.118	<0,5 (0)
				Zink	mg/dm³	0,002	1					МВВ 081/12-0413-07	<0,005 (0,002)

Table 31.Результати дослідженні фітопланктону басейну р. Іква
Phytoplankton data of the Ikva River (June, 2010)

Пункт відбору Sampling site	Кількість видів/ n species	Чисельність, тис. кл./л N cells, th. cells/l	Біомаса, мг/л Biomass, mg/l	Домінанти Dominants
Р. Іква, верхів'я, с. Лукаші Ikva, upper section	34	1912,5	1,76	*Desmodesmus communis* (=*Scenedesmus quadricauda*), *Oocystis borgei*
Р. Іква, с. Богданівка Ikva, Bohdanivka	43	2350,0	2,20	*Desmodesmus communis* (=*Scenedesmus quadricauda*), *Coelastrum astroideum*
Р. Іква, с. Берег Ikva, Bereg	66	6480,0	5,01	*Microcystis pulverea*, *Coelastrum astroideum*, *Gomphosphaeria lacustris*, *Desmodesmus communis* (=*Scenedesmus quadricauda*)
Р. Іква, нижче м. Дубно Ikva, downstream Dubno	44	3210,0	2,78	*Desmodesmus communis* (=*Scenedesmus quadricauda*), *Coelastrum astroideum*
Млинівське водосховище, с. Млинів Mlyniv reservoir, Mlyniv	54	5450,0	4,21	*Dinobryon divergens*, *Microcystis aeruginosa*, *Euglena sp.*, *Desmodesmus communis* (=*Scenedesmus quadricauda*), *Coelastrum astroideum*
Р. Іква, с. Острів village Ostriv	85	7070,0	6, 78	*Pandorina morum*, *Aulacoseira granulata*, *Coelastrum astroideum*
Р. Тартацька River Tartacka	42	1825,0	1,32	*Nitzschia acicularis*, *Navicula hungarica v. capitata*, *Desmodesmus communis* (=*Scenedesmus quadricauda*)
Р. Мовчанка River Movchanka	64	4762,5	2,43	*Oscillatoria ornata*, *Navicula hungarica v. capitata*, *Euglena sp.*, *Euglena granulata*, *Lepocinclis ovum*

О. Мантурова
O. Manturova

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Norwegian Institute for Water Research

Gaustadalléen 21 • NO-0349 Oslo, Norway
Telephone: +47 22 18 51 00 • Fax: 22 18 52 00
www.niva.no • post@niva.no