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DNIEPER RIVER BASIN MANAGEMENT PLAN IN BELARUS

Report

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Abbreviations

AWO	Artificial water object
BAT	Best available techniques
BC	Bovine cattle
Belarus	The Republic of Belarus
Belhydromet	State Institution “Republican centre for hydrometeorology, control of radioactive contamination and environmental monitoring” (MNREP, Belarus)
BNTU	Belarusian National Technical University
BSCA	Belarusian State Centre for Accreditation
CRICUWR	Republican Unitary Enterprise “Central Research Institute for Complex Use of Water Resources” (MNREP, Belarus)
CWSS	Centralized water supply systems
EPIRB Project	Project “Environmental Protection of International River Basins”, funded by the EU
EU	European Union
EUWI+	European Union Water Initiative for Eastern Partnership Countries (EUWI+ 4 EaP)
GDP	Gross Domestic Product
GW	Groundwater
GWB	Groundwater body
HMWB	Heavily modified water body
Institute of Geology	Branch «Institute of Geology» Republican Unitary Enterprise «Research and Production centre for Geology» (MNREP, Belarus)
IUCN	International Union for Conservation of Nature
MAC	Maximum allowable concentration
MNREP	Ministry of Natural Resources and Environmental Protection of the Republic of Belarus (MNREP, Belarus)
NAS of Belarus	National Academy of Sciences of Belarus
NEMS	National environmental monitoring system
NSSD-2030	National strategy for sustainable social and economic development of the Republic of Belarus for the period up to 2030
PA	Plan of action
RBMP	River basin management plan
RCAC	State Institution "Republican Center for Analytical Control in the Field of Environmental Protection" (MNREP, Belarus)
SEDP	Program of social and economic development of the Republic of Belarus for 2016-2020
SIUWR	Scheme for the integrated use of water resources

SPAs	Specially protected natural areas
SWB	Surface water body
SWC	State water cadastre of the Republic of Belarus
SWL	Solid waste landfill
TCCP	Technical code of common practice (national regulatory document, the Republic of Belarus)
VMWS	Vileyka-Minsk water system
Water Convention	United Nations Economic Commission for Europe (UNECE) - Convention on the Protection and Use of Transboundary Watercourses and International Lakes
WFD	Directive of the European Parliament and the Council of the European Union No.2000/60/EU of 23 October 2000, establishing the basis for Community action in the field of water policy (Water Framework Directive)
ZHILKOMHOZ	Housing and communal service

1 EXECUTIVE SUMMARY

1.1. Project brief

The European Union Eastern Partnership (EaP) is a policy initiative launched at the Prague Summit in May 2009. It aims to deepen and strengthen relations between the European Union and its six Eastern neighbours: Armenia, Azerbaijan, Belarus, Georgia, the Republic of Moldova and Ukraine.

In recent years, the countries of the Eastern Partnership have demonstrated a willingness to align their water policies and practices with the general principles and specific requirements of the EU Water Framework Directive (WFD), as well as other thematic and sectoral water directives and UN Multilateral Environmental Agreements (MEAs). Moreover, Georgia, Moldova, and Ukraine have made commitments to reform their water policies and implement the EU water acquis as part of Association Agreements signed with the EU in 2014.

It is in this context that the European Union Water Initiative Plus for the Eastern Partnership (EUWI+) for Eastern Partnership Countries was initiated by the Directorate-General for Neighbourhood and Enlargement Negotiations (DG NEAR) of the European Commission.

The European Union Water Initiative Plus for the Eastern Partnership (EUWI+) was launched in September 2016 to assist the 6 Eastern Partner countries to approximate their legislation to the EU Water Framework Directive and its associated directives. Its objective is to improve the sustainable management of water resources with a focus on trans-boundary river basin management.

EUWI+ focuses on five thematic areas:

1. Legislation, policy development and institutional strengthening
2. Laboratory and monitoring systems strengthening
3. River Basin Management Plan development
4. River Basin Management Plan implementation
5. Public awareness, communication, and data/information management

The OECD and UNECE are implementing activities under thematic area 1. Thematic areas 2–5 are implemented by an EU Member States Consortium comprised of the Environment Agency Austria (UBA) and the International Office for Water (OIEau/IOWater) of France. Experts from other EU Member States will also be involved in activities of the project.

The budget for these thematic areas for all 6 countries amounts to Euro 24.6 million in total, which is financed by the European Union (Euro 23.5 million grant) with contributions from the Governments of Austria and France. Its planned period of implementation is from September 2016 until August 2020 (48 months).

The project has developed a website (http://euwipluseast.eu/en/) to publish and disseminate all data, information and services developed and used in the frame of this project.

1.2. Executive summary of the current report

The *European Union Water Initiative Plus for the Eastern Partnership* (EUWI+) was launched in September 2016 to assist the 6 Eastern Partnership countries in approaching the EU Water Framework Directive (WFD) and its associated directives. The project objective is to improve the sustainable management of water resources with a focus on trans-boundary river basin management.

The present package contains the Dnieper River Basin Management Plan in the Republic of Belarus for the period 2019-2024.

These documents have been elaborated by three Belarusian experts from the Central Research Institute for Complex Uses of Water Resources in Minsk with the continuous support of EUWI+ experts' team. A first Draft RBMP has been produced during the former project EPIRB. EUWI+ gave a support to refine this Draft in line with the Water Framework Directive and the Belarusian regulation i.e. the 2014 Water Code and, as secondary legislation, the Technical Code of Common Practice (TKP) about requirements for the development, compilation and completion of draft River Basin Management Plans.

The River Basin Management Plan consists of:

A report describing the characterization of the River Basin, the main issues, the protected areas, the water bodies and their status, the environmental objectives and the programme of measures,

An annex with tables required by the TKP,

An annex with additional maps.

An additional report about diffuse sources assessment has been produced in order to improve the estimation of diffuse sources and to propose a Draft methodology for such estimation in Belarus.

The Dnieper River Basin (RB) concerns 3 countries (Russia, Belarus, Ukraine). The Dnieper RBMP in Belarus covers 63,700 km² (without its main tributary Pripyat), is occupied by 4.8 million inhabitants (incl. Minsk), and is one of the most developed industrial areas. Agricultural land concerns 64% of its surface.

Each year, around 550 million m3 are abstracted, especially for domestic uses. The average annual river flow and groundwater resources are estimated to 16,500 million m3.

75% of the monitored rivers are of good quality. The climate change increases the negative consequences of dry periods.

15 water users are responsible for more than 90% of the total volume discharged treated wastewater. Minsk Water Treatment Plant represents 38% of the total volume discharged.

Locally, fertilisers and pesticides from agriculture contribute to pollution.

Radioactive pollution from Chernobyl disaster is decreasing significantly.

Hydromorphology is disturbed by 73 obstacles, 17 reservoirs, and 1610 km of straightening rivers.

The objectives of the RBMP for 2024 are: good quality for most of the rivers, 50% of pollutants discharges reduced, 4% of groundwater abstraction reduced, 100% of water supply in settlements with more than 10,000 people, 95% of urban population and 80% of rural population with high quality tap water.

During the period 2019-2024, the programme of measures is estimated to 233 million € incl. 65 million € to improve the Minsk Water Treatment Plant. This amount represents 0.2% of the Gross Domestic Product (GDP) generated per year in the River Basin.

The Dnieper River Basin Management Plan has been approved by the Basin Council held in Gomel on 25th October 2018.

2 TERMS AND DEFINITIONS

The following terms and definitions are used in this Dnieper RBMP:

Water resources – surface and groundwater which are used or can be used in economic and other activities.

Water body – the concentration of water in artificial or natural depressions of the earth's surface or in its depths, which has sharp boundaries, volume and characteristics of the hydrological or groundwater regime.

Reservoir – a surface water body in the depression of the earth's surface, characterized by slow motion of water (flowing) or its complete absence (non-flowing).

Water protection zone – a territory adjacent to surface water bodies where a regime of economic and other activities is established, which ensures the prevention of their pollution and impurity.

Water use – the use of water resources and (or) the impact on water bodies in the implementation of economic and other activities.

Water users – legal entities, citizens, including individual entrepreneurs, who use water resources and (or) have an impact on water bodies in the implementation of economic and other activities.

Water course – a surface water body, characterized by the motion of water in the direction of the slope.

Water management system – a set of water bodies and hydraulic structures and devices, functionally interrelated.

The probability of exceedance (provision of a hydrological quantity) – a probability that considered value of the hydrological quantity can be exceeded (or not exceeded) among the set of all its possible values.

Restoration of a water body – carrying out a set of actions aimed at achieving standards for the water quality of surface water bodies and hygienic standards for the water safety of water bodies for household, drinking, cultural and community (recreational) use.

Hydrological regime – alterations in time and space of surface water body state, including changes in depth, flow rate, volume and temperature of water in a surface water body, including those caused by natural and climatic conditions, consequences of economic and other activities.

Hydraulic engineering structures and devices – engineering structures and devices designed for extraction (intake), transportation, water treatment, wastewater discharge, regulation of water flows, navigation needs, water protection and prevention of harmful effects of water (water intake structures, canals, dikes, dams, gateways, waterworks, pumping stations, water pipelines, collectors and other similar engineering structures and devices).

Water pollution – an income to water (water bodies), finding and (or) occurrence as a result of harmful effects substances, physical factors, microorganisms, the properties, location or amount of which lead to negative changes in physical, chemical, biological and other indicators of the state of water bodies, including the excess of standards in the field of water protection and use.

Flooding – covering the area with a layer of water during the high water period, flood runoff and flooding, or due to the installation of a water-supply structure in the river bed, as well as with the retention of local runoff in relief depressions.

Channel – an artificial watercourse in the depression or embankment, intended for transportation, discharge of water, regulation of water flows, as well as for the needs of navigation.

Normal water level (NWL) – the highest specified retaining level of the headwater, which can be maintained in normal operating conditions of hydraulic structures. The NWL provides the specified full volume of the

reservoir. And the operation of its facilities (dams, dikes, water disposals, water intakes, etc.) is conducted in compliance with the normal reliability reserves provided for by the project.

Separate water use – a prerogative right of one legal entity for water use conducted on the basis of the state act for the right to separate water use, or the right to use excavated tanks, located within the boundaries of land properties granted to legal entities, citizens, including individual entrepreneurs, in the prescribed manner, and technological water bodies, justified by documents certifying land rights.

Objects that have an impact on water bodies – objects located on surface water bodies within the territory of their water protection zones and coastal strips.

Water protection – a system of measures aimed at preventing or eliminating pollution, water clogging, as well as their conservation and restoration.

Environmental Impact Assessment (EIA) – an activity of identifying, analyzing and accounting of direct, indirect and other environmental impacts of a planned economic or other activity in order to decide whether it is possible or impossible to conduct it.

Surface water body – a natural or artificial reservoir, a watercourse, a permanent or temporary concentration of water having sharp boundaries and characteristics of a hydrological regime.

Groundwater body – a concentration of water in the depths, which has sharp boundaries, volume and characteristics of the groundwater regime and consists of one or several aquifers.

Underflooding – a rise of the groundwater level as a result of rising water horizons when constructing reservoirs, filled out ponds and building of hydraulic structures, in the result of saturation of soils when filtering water through the bottom and banks of canals, water losses from the water supply network, siltation of river beds, etc.

Water loss – the amount of water lost during its transportation, storage, redistribution and cooling, as a result of which it does not reach the water user or can be consumed above permitted standard.

Coastal strip – a part of a water protection zone directly adjacent to a surface water body, where on the implementation of economic and other activities are imposed more strict requirements than in the rest of the water protection zone.

Pond – an artificial reservoir with a surface area of water of not more than 100 hectares, created for the purpose of accumulating and storing water.

Water consumption (m^3/s) – the volume of water flowing through the water cross-section of flow per unit time.

Efficient (sustainable) use of water resources – water use when a set of activities is carried out to ensure the preservation of water resources, reduction of water losses, prevention of pollution, water pollution.

Groundwater regime – changes in time and space of levels (pressure), temperature, chemical, gas and microbiological composition and other characteristics of groundwater.

River – a natural watercourse with a constant flow, which has a clearly defined course with a length of 5 kilometers or more.

River basin – a part of the earth's surface, including soils and aquifers, where the water flows into a separate river.

Stream – a natural watercourse with a length of up to 5 kilometers.

Sewage water – water discharged from residential, public and industrial buildings and structures after using them in economic and other activities, as well as water occurring during precipitation, snow melting, watering and washing of road surfaces (watering actions) within the territory of residential areas, industrial facilities, construction sites and other facilities and discharged into the environment, including through the sewage system.

Technological water bodies – artificial reservoirs, water streams specially created for cooling, evaporation, averaging, settling of sewage, lowering the water level (cooling ponds, evaporation ponds, averaging ponds, supply canals for pumping stations and other similar objects), as well as artificial reservoirs, specially created for fire-fighting needs (fire reservoirs), ponds and canals, specially created for fish breeding and farming using hydraulic structures and devices designed to regulate water streams and discharges of sewage waters.

3 PREAMBLE

In 2014–2016, during the implementation of the European Union's international project "Environmental Protection of the International River Basins" (EPIRB Project) and on the basis of Articles 12 and 15 of the Water Code of the Republic of Belarus of 30 April 2014 №149-3, a project of the Dnieper River Basin Management Plan (RBMP) in Belarus has been developed.

The development of the Dnieper RBMP was based on the Directive of the European Parliament and the Council of the European Union No.2000/60/EU of 23 October 2000, which establishes the basis for the EU's activities in the sphere of water policy (Water Framework Directive, WFD) and its guiding documents. The previous national experience of the republic in the development of the SIUWR (scheme for the integrated use of water resources) is also taken into account, the requirements for which partially coincide with the requirements of the WFD while developing the RBMP.

The project of the Dnieper RBMP on the territory of the Republic of Belarus was prepared by specialists of the RUE "CRICUWR" in association with its partners, such as Belhydromet and RCAC in 2014–2016. The following experts were involved in the preparation of this RBMP project: Vladimir Korneev, Kanstantsin Tsitou, Lubov Hertman, Vladimir Anufriev, Aliaksandr Pakhomau, Ivan Bulak, Asya Penkovskaya, Ekaterina Popova (CRICUWR); Genady Tischikov, Igor Tischikov (Belhydromet). The following experts assisted in preparing the RBMP project of the Dnieper River Basin: Olga Vasniova, Igor Vitsen (branch «Institute of Geology» RUE «Research and Production Center for Geology»), Vasilij Pashkevich (Institute for Nature Management of NAS of Belarus), Timothy Turner, Zurab Jincharadze, Bernardas Paukstis, Birgit Vogel, Paul Bijuis, Romina Alvarez, Peter Roncak (group of experts of the EPIRB Project).

The Order of the Ministry of Natural Resources and Environmental Protection of the Republic of Belarus No.41-RD of 25 February 2016 approved the Dnieper Basin Council consisting of 16 people. The meeting of this Council took place on 3 March 2016 in Mogilev. The Dnieper Basin Council reviewed and approved the project of Dnieper PBMP on the territory of Belarus and recommended to write a number of clarifications in the program of measures. The program of measures was improved and delivered in the final version of the Dnieper RBMP project.

The technical code of the common practice TCCP "Environmental protection and nature management. Requirements for the development, designing and execution of the RBMP projects" was adopted 17.06-14-2017 (33140) on June 01, 2017 in the Republic of Belarus. The specified TCCP significantly expanded the requirements for the content of the RBMP in terms of both the characteristics of the basin and the information and tabular and cartographic material, taking into account the quintessence of the use of the WFD best approaches and recommendations and integrated water use and protection schemes (SIUWR) previously developed in the Republic of Belarus. This refers both to the use of the WFD's experience in assessing the ecological status (state) of water bodies, environmental goals and measures to achieve and maintain good environmental state and water management issues taking into account the experience of SIUWR developing.

In 2018 the project of the Dnieper RBMP was finalized in accordance with the above mentioned, in order to coordinate RBMP project with the TCCP requirements 17.06-14-2017 (33140), taking into account more comprehensive and representative assessments by including information for 2016–2017.

The improvement of the Dnieper RBMP was carried out within the framework of the international technical assistance project "European Union Water Initiative for Eastern Partnership Countries (EUWS +)" by the following experts: Vladimir Korneev, Aliaksandr Pakhomau, Ivan Bulak (CRICUWR). Great methodological and practical assistance in improving the Dnieper RBMP was provided by the international expert of the EUWI + Philippe Seguin.

In the preparation of the Dnieper RBMP project within the framework of the EPIRB project in 2014–2016 and in the project's improvement within the framework of the project EUWI+ in 2018 significant methodological assistance and contribution was provided by A.Stankevich.

The authors enclose gratitude to the specialists of the Ministry of Natural Resources and Environmental Protection of the Republic of Belarus for essential comments, suggestions and support at all stages of the development and improvement of the Dnieper RBMP – Tatsiana Slizh, Victoria Voranava, Sergei Zavyalov, as well as specialists from Mogilev, Gomel, Minsk and Vitebsk regional and Minsk city committees of natural resources and environmental protection, Belhydromet, Institute of Geology, RCAC. The authors are grateful to Ekaterina Popova for assistance in preparing the document and tabular material presented in Appendix A to the Dnieper RBMP.

The data on the report “Scheme for the integrated use and protection of the Dnieper River Basin waters” (RUE “CRICUWR”) developed in 2013–2014 by RUE "CRICUWR" under the guidance of Ph.D. of Technical Sciences Asya Penkovskaya on the instructions of the Ministry of Natural Resources and Environmental Protection of the Republic of Belarus with funding from the republican budget were used while preparing the Dnieper RBMP on the territory of Belarus and its improvement.

The Dnieper RBMP is aimed at the implementation by state and other organizations by developing water management and other activities that are included in governmental programs, action plans and other documents in the field of environmental protection and the rational use of natural resources.

The Dnieper RBMP, which is designed and executed in accordance with the requirements of TCCP 17.06-14-2017 (33140) “Environmental protection and environmental management. Requirements for the development, designing and execution of RBMP projects river”, consists of the Explanatory Note with 104 sheets, sets of tabular material presented in Appendix A and consisting of 21 main tables and 25 additional tables and cartographic material (Appendix B) and the main results of the pilot project “Analysis and Mapping of Flood Risk in the Dnieper Basin, including the identification of areas which are mostly at risk, field studies of hazardous areas, mapping and preparation of a preliminary scope of protective measures on the example of the city of Dobrush in Gomel Region "(Annex B).

The measures proposed in the Dnieper RBMP aimed at improving the ecological state (status) of surface water bodies (their parts), indicating the dates and expected indicators for their implementation, have been previously coordinated with the Vitebsk, Minsk, Mogilev and Gomel Oblast, and Minsk City Committee of Natural resources and environmental protection.

In 2018, upon condition of its approval, the implementation of the Dnieper RBMP is to be carried out in two stages.

The first stage (2019–2024) includes the realization of priority measures, the implementation of which will help to maintain the "good" or "excellent" ecological state (status) of water bodies and the progressive decrease of negative impacts on water bodies.

The second stage (2025–2030) includes additional measures, the implementation of which will improve the ecological state (status) of surface water bodies which are at risk of not achieving a “good” ecological state (status).

The translation into English was made by Yuliya Shepeleva (translator of the scientific-organizational department of the branch “Institute of Geology”).

4 CHARACTERISTICS OF THE DNIEPER RIVER BASIN ON THE TERRITORY OF BELARUS

4.1 Physical and geographical characteristics

4.1.1 Geographical location of the basin

The Dnieper River flows through the territory of three countries of Eastern Europe - the Russian Federation, the Republic of Belarus and Ukraine. The Dnieper is the third largest transboundary stream flow in Europe after the Danube and Volga rivers, with a total basin area of 504,000 km^2. It is also the fourth longest river in Europe (2,200 km) after the Ural, Volga and Danube rivers. 7.3% of the water catchment area of the Dnieper basin is within the Russian Federation (36,540 km^2), and 23,5% is within the Republic of Belarus (118,360 km^2). The largest part of the water catchment area of the basin (or 69,2%) is located within Ukraine (349,100 km^2). The map of the Dnieper basin is represented in Figure 1.1.

The Dnieper river basin is a multi-industry complex, which has a high natural, social and economic value. Apart from the fact that socially important natural resources (for example, water, land and forest resources) are concentrated within the basin territory, it also represents a valuable resource base for a wide range of stakeholders, including commercial, industrial and governmental organizations (for example, industrial enterprises, land users, water users, government structures, control and regulatory bodies, etc.). Large urban formations, as well as a great number of small and medium agglomerations are concentrated in the Dnieper basin.

The Dnieper River is the first river in terms of size and water content, which is flowing through the territory of Belarus. It heads from the southern spurs of the Valdai Hill from a small swamp (at an altitude of 236 m above sea level) in 2.0 km southeast away from Aksenino village in the Andreevsk district in the Smolensk region of Russia. It flows into the Dnieper-Bug estuary of the Black Sea (Ukraine).

The river flows through the Vitebsk, Gomel and Mogilev regions within the territory of Belarus.

The length of the Dnieper River is 2145 km (before the reservoir construction the river the length reached 2285 km). Within the territory of Belarus, the length of the Dnieper River is 689 km. The water catchment area is 504 thousand km^2. Within the territory of Belarus, the catchment area is 63.7 thousand km^2 (without the Pripyat basin).

From the head to the mouth of the Pripyat River the length of the river is 1182 km, the catchment area is 225 thousand km^2. As far as the city of Orsha, the river flows in the south-west direction. Below Orsha the river flows in the south direction. Above Orsha it flows through the urban area Viale, and is supported by the Kiev reservoir which was filled in 1966 to the mark of the normal headwater elevation reaching 103 m. The total fall is 141.5 m, the average slope is 0.12 ‰, and the weighted average is 0.09 ‰. The coefficient of the river meandering is 2.09. A slop map and elevation map are given in Appendix B (figure 15).

The catchment area has irregular shape and is greatly expanded in the middle part and is located within the Central Berezino water-glacial plain, the Orsha-Mogilev Plateau, which in the southeast direction smoothly passes into the extensive swampy lowland of the Belorussian Polesye.

Figure 1.1 Map of the Dnieper River Basin

According to the peculiarities of the structure of the valley, the stream bed and the flow conditions, Dnieper river can be divided into three areas: 1 – the length of 410 km, head – Smolensk (Russia); 2 – the length of 239 km, Smolensk – Mogilev; 3 – the length of 533 km, Mogilev – the mouth of the Pripyat river.

Within the area Smolensk – Mogilev, the valley of the river is trapezoidal and trough-shaped. Its width is 0.8-3.0 km between Smolensk (Russia) and Dubrovno (Belarus), and in some places below it extends to 10 km. Slopes are moderately steep, patchily abrupt and sloping, terraced (up to 4-5 terraces), with the ledges height of 12–30 m. They are scattered by ravines, beams and tributary valleys, mostly open and plowed. Soils are sandy loamy and loamy. There are insignificant groundwater discharges.

The flood basin is represented by the lower double-sided terrace, rising above the low-water level by 5–8 m, with the width from 100 m to 1 km at the beginning of the area and up to several kilometers at the end. The surface of the flood basin is moderately crossed. It is opened and plowed; less often covered with shrubs or forest, and is composed of sandy loam and sand. It can be flooded only by high water for a period of 5–10 days.

The river bed with a side-channel type of channel process, is slightly meandering (C = 1,02), with width of 60–120 m. Between urban areas of Gatkovschina and Orsha in some places it extends to 1.3 km. It distinguishes by smooth bends and long straight areas with a great number of rifts and full of cripples. Sometimes small flooded sandy islands with a length of 15–170 m and a width of 7–80 m occur. The depth is 2–4 m. Within the rifts the depth is about 1 m, and the largest depth is 7–8 m. The stream velocity varies from 0.2 to 1.3 m/s. The prevailing current velocity is 0.4–0.5 m/s.

The bottom is flat. It is sandy and sandy-gravelly at greater length. The coastal zone is often dripped with stones and boulders, often rising above the water. 9 km above Orsha, near Kobelyaki (near the Prydniprovie area), the river splits the ridge of Devonian limestones, forming the Kobelyak thresholds with the length of about 200 m. The banks are predominantly steep, with a height of 2–10 m, sometimes they go below to 0.5–1.0 m. They are overgrown with shrubs, less often opened, and collapsed on the bends, composed of sandy loams, boulder and barren loams.

On the area from Mogilev to the mouth of the Pripyat river, the valley to the mouth of the Sozh river is mainly trapezoidal, with a width of 5–10 km and more, with a dominant right slope with a height of 15–35 m. Below the valley is not well-defined, with mild slopes, which are merging with the surrounding area of the swampy Polesye lowland.

The flood plain is two-sided, mostly opened, meadow, with a width of 3–6 km, and below Zhlobin it extends to 8–10 km. The surface is strongly rugged by old creeks, sleeves, ducts and bays. It is accompanied by elevated ridge-shaped areas of sandy hillocks and channel banks. Depressions are represented by swamps. Soils are sandy loamy and loamy, less often peaty. It can be flooded for a period of 1–2.5 months.

The bed is strongly wandering (C = 1.11). To the mouth of the Lahva River, the bed is not meandering with a collateral type of process. Throughout the rest of the area, the bed is free meandering, often branched by sleeves and ducts, forming numerous low flooded sandy islands with the length from 50 m to 3 km.

The width of the river before the inflow of the Lahva River is 80–120 m, below the mouth of the Sozh river the width is 150–600 m, from the mouth of the Sozh river before the inflow of the Borzna river the width is 0.8–1.5 km. It can occasionally reach several kilometers in the area of the support by the Kiev reservoir. Throughout a long area the river bed is strongly meandering, is replete with ruts (about 200) and shelves, mostly occurred in the area between the inflow of the Drut and Sozh rivers, where the prevailing depths are 1–1.5 m. Throughout the rest of the area, the depth reaches 2–3 m, and at the end of the area increases to 10 m.

The current velocities are 0.2–0.8 m/s, and within the rifts they reach 1.1 m/s. The bottom is flat, sandy, often sandy-gravelly and stony, sometimes sandy-silty. The banks vary from slightly slopping to steep and precipitous (the height from 0.5 m to 10.0 m). They are destroyed on bends. There are shore fortifications in some areas.

Within the borders of Belarus, the valley is predominantly trapezoid; below the mouth of the Sozh River the valley is featureless. The width of the valley to Mogilev is 0.8–3.0 km, below (to the mouth of the Sozh River) is 5.0–10.0 km. Within the boundaries of the Polesye lowland, the valley merges with the surrounding terrain. Slopes of the valley are moderately steep and abrupt, with a height of 12–35 m, rugged by ravines, logs, tributary valleys.

Over a long distance from Mogilev the flood plain is a two-sided terrace that rises above the low-water level by 5–8 m. Its width is 0.1–1.0 km. From Mogilev to Zhlobin it extends to 6 km; within the boundaries of Gomel Polesye it extends up to 10 km. The surface of the flood plain below Mogilev is rugged by old channels, sleeves, ducts and bays, mostly opened and plowed. There are also raised hilly areas, sandy hillocks and channel banks within this territory.

The width of the river is 60–120 m. Between the mouths of the Berezina and Sozh rivers the width is 0,2–0,6 km. Below this area, the width reaches 0.8–1.5 km, and in the zone of the support by the Kiev reservoir the width is 3–5 km.

The relief is flat-hilly. The most elevated northern part is a complex system of large-hilly moraine hills (Orsha, Minsk), alternating with slightly bent, often swampy lowlands and heavily disjointed plateau-like areas. Relative heights of particular hills range from 30–50 to 120 m. The central part, covering the catchments areas of the Berezina and Sozh rivers, is mostly flat. Sometimes there can be wavy and shallow areas of the basal moraine with relative heights of 5–30 m.

The left bank to the territory Zhlobin is heavily disjointed by valleys, ravines, gullies and it is elevated for about 40–60 m from the right bank. The southern part of the catchment area is associated with dune-hilly sandy formations with the height of 5–8 m and separate highly eroded moraine hills, uplands and ridges up to 10–60 m high above the surrounding terrain.

4.1.2 Climate

Moderate continental climate in the Dnieper river basin, as well as throughout the territory of Belarus, is formed under the influence of a number of factors. The main of these factors are the geographical location of the territory, atmosphere circulation, the flat terrain structure. The basic characteristics of the climate are due to the location of the research area in middle latitudes, the absence of mountains, relative distances from the Atlantic Ocean.

Atmosphere circulation causes a constant change of air masses. Western transportation of air masses from the Atlantic enables to the formation of winds in the lower layers of the atmosphere of the western, north-western and south-western directions, which bring cloudy weather and rains in the summer, snow and thaw in winter. The location of the Dnieper valley in the eastern part of Belarus determines the great climate continentality within this territory in comparison with the western part of the basin and the predominance of air masses from the east and northeast. From the east, dry continental air masses enter the territory, bringing fine weather in winter with strong frosts, and dry and hot weather in the summer. From the north-east arctic continental air masses enter he territory, bringing fall of temperature with a gusty wind and blend of sun and clouds. Tropical air from the south is rarely observed and is accompanied by a significant increase in the temperature of the surface air layer.

The thermal regime of the river basin is characterized by a gradual temperature increase in the direction from the north-east to south-west (in summer to the south-east). The average annual temperature varies from 4.5 to 7.0 °C, the average monthly temperature in July varies from +17.0 to + 18.5 °C, in January it ranges from -8.0 to -4.5 °C (Figure 1.2). During the warm period of the year, the isotherms have a latitudinal distribution, so the air temperature in the north-south direction increases by 0.5 °C for every 200 km. During the winter period, the isotherms have a latitudinal distribution, and the temperature in the west-east direction is reduced by 0.5 °C for every 100 km. The last spring frosts are common with the first decade of May, the first autumn frosts are common with the end of September and the first decade of October.

Research area is located in a zone of sufficient moisture with an average annual rainfall of 600–700 mm, while within the elevations the amount of precipitation is slightly higher – 650-700 mm. Within the lowlands the amount of precipitation reaches 600–650 mm. The average number of days with precipitation varies from 145 to 195. The maximum number of days with precipitation is recorded in the winter period (December, January), the minimum number is recorded in May and September (Appendix B, figure 17).

Snow cover lies steadily in the north of the basin at the beginning of December and in the south of the basin at the end of December. The disruption of snow cover occurs at the beginning of April in the north and at the end of March in the south.

4.1.3 Geological structure

Main rocks forming the modern relief of the catchment area are represented by glacial (morainic), fluvio-glacial, loesslike, fluvio-lacustrine and eolian (wind-swept) deposits. They are underlain by Tertiary Cretaceous and Devonian water-bearing deposits, often cropping out in the form of chalk or limestone, mainly in the valleys of the Sozh River and its tributaries. Along the left bank, and especially within the Orsha-Mogilev plateau, there are karsts that affect the underground water inflow of rivers and their runoff.

Most of the mineral deposits in the Republic of Belarus are localized in the Dnieper and Pripyat river basins, especially within the Pripyat Trough located on the territory of these basins. They are not only the suppliers of raw material for the country, but they also provide export potential of the country (for example, potassium and rock salt). There are vast reserves of oil and gas within this territory. 60 oil fields have been discovered, while 38 of which are being developed, 13 are being explored and 9 are suspended. Annual amount of the production of natural gas is about 252 million m3. Mineral and resource potential of the Belarusian part of the basin has not been fully realized. Besides, estimated peat reserves localized in this part of the basin are about 3 billion tons, although the residual developed reserves are much smaller.

4.1.4 Soils and vegetation

Composition of soil-forming bottom of the basin is represented by loesslike, boulder and driftless loams, clays, sands, sandy loam and sandy-gravel material, where loamy and sandy loam complexes of ash gray soils were most developed. Loamy varieties are typical for the elevated northern and plateau-like eastern parts of the territory. Loam-sandy and sandy soils prevailing within the plains of the central part, gleyed on sands in combination with water-saturated peat-bog and flood-meadow soils, are widespread in the Polesye lowland.

In the Belarusian part of the Dnieper river basin, forest areas occupy 5.7 million hectares, or 48.6% of the total area. 4.6 million hectares of this area is represented by a wooded area with a total reserves of tree species, reaching up to 799.4 million m3 (or 59.6% of the total reserves of the Republic of Belarus), and 82.5 million m3 of mature and overmature planted vegetation.

The allocation of forests is spotted. Large forest massifs are found in the catchments of right-bank tributaries (the Berezina River, the Drut River). The left bank is much less afforested. Here forests are concentrated within small areas, the largest of which are localized in the lower streams of the Sozh River. Forests are mixed. The main wood species are pine, spruce, and oak.

Pine spruce with small-leaved forest areas prevails in the northeastern part. Pine forests predominate in the middle part. Within Polesye, mixed and swamped broadleaf formations stand out against the background of the pine forests. Alluvial plains of rivers are often covered with oak forests and oak-hornbeam forests. The forest cover of the catchment area is about 25%.

Over 25.6% (or 1.7 million hectares) of the forest resources of the Republic of Belarus are contaminated with radioactive substances as a consequence of the Chernobyl accident. Most of these forests are concentrated within the Belarusian part of the Dnieper Basin. 89.3% of the total contaminated forest area refers to the first radioactive hazard zone (where the pollution level is 1 to 5 Ci/km2 137Cs), 8.4% refers to the second zone (5–15 Ci/km2 137Cs). And 2.3% of the territory was excluded from the economic use, while limited economic use of forest resources is allowed within an area of 320.2 hectares.

Swamps are mostly low-lying, open, significantly drained and developed. They have the largest distribution and size within Polesye, where they are known as "gals". Within the rest of the catchment area, swamps are concentrated as small spots among forests. Marshiness is about 20%, including 11% of bogged forests. Large territories are occupied by bottomland meadows.

An land use map and soil map are given in Appendix B (figures 4, 16).

4.2 Administrative territorial division and social and economic information

4.2.1 Administrative territorial division and social and population

The Belarusian part of the Dnieper basin is located in the eastern part of the republic in 4 administrative regions – Vitebsk (about 16.5% of the territory of the region or 6.62 thousand km^2), Mogilev (about 91.2% of the area or 26.52 thousand km^2) , Minsk (about 32.9% or 13.14 thousand km^2) and Gomel (about 43.2% or 17.44 thousand km^2). On the territory of the Republic of Belarus the total area of the Dnieper basin is 63.72 thousand km^2.

The percentage of the area of the Vitebsk region in the total area of the basin is 10.39%, the Mogilev region – 41.62%, the Gomel region – 27.37% and the Minsk region – 20.62%.

The territory of the Dnieper Basin includes 46 administrative districts (map is given in Appendix B, figure 1).

This includes 6 districts of the Vitebsk region (Orsha, Dokshitsy, Dubrovna, Tolochin, Lepel and Ushachy), 20 districts of the Mogilev Region (Belynichi, Bobruisk, Bykhov, Horki, Dribin, Kirov, Klimovichi, Klichev, Kostyukovichi, Krasnopolle, Krichev, Krugloe, Mogilev, Mstislavl, Osipovichi, Slavgorod, Khotimsk, Chausy, Cherikov, Shklov), 12 districts of the Gomel region (Buda-Koshelev, Vetka, Gomel, Dobrush, Zhlobin, Loev, Korma, Rechitsa, Rogachev, Svetlogorsk, Chechera, Bragin), and 8 districts of the Minsk region (Berezino, Borisov, Krupki, Logoisk, Minsk, Pukhovichi, Smolevichi and Cherven), 41 towns, 26 urban-type and region settlements, more than 15 large rural-type settlements and a great number of smaller settlements (small villages, countryside and etc.).

There are 5 cities on the territory of the Dnieper Basin in the Vitebsk region (Orsha, Baran, Dokshitsy, Dubrovno, Tolochin), 5 urban-type settlements (Bolbasovo, Kopys, Orekhovsk, Kohanovo, Begoml) and rural settlements, the largest of which are Babinichi and Krulevschina.

In the Mogilev region within the territory of the Dnieper river basin there are 15 cities (Bobruisk, Bykhov, Horki, Mogilev, Mstislavl, Kirovsk, Klimovichi, Klichev, Kostyukovichi, Krichev, Osipovichi, Slavgorod, Chausy, Cherikov, Shklov), 6 urban-type settlements (Belynichi, Dribin, Krasnopolle, Krugloe, Elizovo, Khotimsk) and rural settlements such as Hodas and Buinichi.

In the Gomel region within the territory of the Dnieper river basin there are 11 cities (Buda-Koshelevo, Gomel, Vetka, Dobrush, Zhlobin, Rechitsa, Vasilevichi, Rogachev, Svetlogorsk, Chechersk, Komarin), 7 urban settlements (Uvarovichi, Terekhovka, Streshin, Loev, Korma, Zarechye, Parichy), 2 district settlements (Kostyukovka, Bolshevik) and rural settlements – Eremino, Pributki, Ozershchina and Belitsky.

In the Minsk region, 10 cities are located on the territory of the Dnieper Basin (Berezino, Borisov, Krupki, Logoysk, Zaslavl, Maryina Gorka, Smolevichi, Zhodino, Cherven and the capital Republic of Belarus – Minsk), 5 urban settlements (Bobr, Kholopenichi, Rudensk, Svisloch, Smilovichi), 1 district village (Zeleny Bor), and rural settlements such as Loschnitsa, Novosady, Lesnoy, Kolodischi, Zhdanovichi, Gatovo, Dryzhniy and others.

The area and location of the Dnieper River Basin defined the demographic structure and population living in the territory of this basin (see Table 1.2).

At the begging of 1 January 2013, in the Vitebsk region, there were 4786,301 thousand people (4076,267 thousand people of the urban population or 79,2% respectively, and 710,031 thousand people of the rural population or 20,8% respectively) (see table 1.2).

The average life duration expectancy in the country is 72.2 years. The expected life duration for urban residents is 73.5 years, for rural people is 68.4 years, including for men – 66.7 years, for women – 77.6 years.

The greatest life expectancy among residents of the city of Minsk is 74.9 years, especially for women – 79.4 years. The least expected life expectancy for rural residents of the Mogilev region is 66.5 years and for men in the Minsk region is 65.3 years.

The largest area of the Dnieper basin and the concentration of large industrial and population centers determined the largest density of population in the republic (73.63 people per 1 km^2). At the same time, the greatest density of the population is typical for the Minsk region reaching 185.01 people per 1 km^2.

In large cities such as Minsk, Gomel, Mogilev, Orsha, Zhodino and Bobruisk, the population density exceeds 2000 people per 1 km^2. In Minsk it reaches 6201.56 people per 1 km^2. The lowest population density is found in Krasnopolle and Klichev districts of the Mogilev region (8.42 and 8.79 people per 1 km^2) and Bragin district of the Gomel region (6.67 people per 1 km^2).

Table 1.2 –Number and population density in the Dnieper river basin

(as of 1 January, 2013)

District	Basin area, km^2	The population in the region, thousand people/%			Population in the basin, thousand people, total /%,			Population density, people/km^2
		total	urban	rural	total	urban	rural	
Vitebsk region								
Dokshitsy district	2108.87	22794 /100	9631 /42.3	13163 /58.7	22794 /100	9631 /42.3	13163 /58,7	10.81
Dubrovno district	1149.72	14196 /100	7079 /49.9	7117 /50.1	13202 /93	6584 /49.9	6618 /50,1	11.48
Lepel district	728.88	32764 /100	17828 /54.4	14936 /45.6	30143 /92	16402 /54.4	13741 /45,6	41.36
Orsha district	1506.48	156411 /100	132911 /85.0	23500 /15.0	137642 /88	116962 /85.0	20680 /15,0	93.79
Tolochin district	1049.02	24478 /100	13875 /56.7	10603 /43.3	17135 /70	9713 /56.7	7422 /43,3	16.33
Ushachi district	74.47	13236 /100	5974 /45.1	7262 /54.9	662 /5	299 /45.1	363 /54,9	8.89
Total for the region	6617.44	263879/100	187298 /71.0	76581 /29.0	221578	159591 /72.0	61987 / 28,0	33.48
Mogilev region								
Mogilev	118.5	381353 /100	381353 /100	–	381353 /100	381353 /100	–	3218.17
Bobruisk	90	217546 /100	217546 /100	–	217546 /100	217546 /100	–	2417.18
Belynichi district	1419.5	18459 /100	9887 /53.6	8572 /46.4	18459 /100	9887 /53.6	8572 /46,4	13.00
Bobruisk district	1071.42	16638 /100	–	16683 /100	11178 /67	–	11178 /100	10.40
Bykhov district	2263.2	29254 /100	17185 /58.7	12069 /41.3	29254 /100	17185 /58.7	12069 /41,3	12.93
Horki district	1284.3	45887 /100	34008 /74.1	11879 /25.9	45887 /100	34008/74.1	11879 /25.9	35.73
Dribin district	766,5	9661 /100	2945 /30.5	6716 /69.5	9661 /100	2945 /30.5	6716 /60.5	12.60
Kirov district	1295,2	19106 /100	8646 /45.3	10460 /54.7	19106 /100	8646 /45.3	10460 /54.7	14.75
Klimovichi district	1542,8	24497 /100	16270 /66.4	8227 /33.6	24497 /100	16270 /66.4	8227 /24.6	15.88
Klichev district	1800,3	14923 /100	7512 /50.3	7411 /49.7	14923 /100	7512 /50.3	7411 /49.7	8.29
Kostyukovichi district	1493,8	22894 /100	15977 /69.8	6917 /30.2	22894 /100	15977 /69.8	6917 /30.2	15.33

District	Basin area, km^2	The population in the region, thousand people/%			Population in the basin, thousand people, total /%,			Population density, people/km^2
		total	urban	rural	total	urban	rural	
Krasnopolle district	1223,0	9363 /100	5757 /61.5	3606 /38.5	9363 /100	5757 /61.5	3606 /29.5	7.66
Krichev district	777,5	31815 /100	26007 /81.7	5808 /18.3	31815 /100	26007 /81.7	5808/19.3	40.92
Krugloe district	881,8	13827 /100	7648 /55.3	6179 /44.7	13827 /100	7648 /55.3	6179 /44.7	15.68
Mogilev	1895,4	40230 /100	–	40230 /100	40230 /100	–	40230 /100	21.23
Mstislavl district	1332,5	20781 /100	10343 /49.8	10438 /50.2	20781 /100	10343 /49.8	10438 /50.2	15.60
Osipovichi district	1265,68	47347 /100	34286 /72.4	13061 /27.6	30775.6 /65	22286 /72.4	8490 /27.6	24.32
Slavgorod district	1317,8	12781 /100	7286 /61.2	5495 /38.8	12781 /100	7286 /61.2	5495 /38.8	9.70
Hotimsk district	858,9	10389 /100	6240 /60.1	4149 /39.9	10389 /100	6240 /60.1	4149 /39.9	12.10
Chaussy district	1471,4	18125 /100	10505 /58.0	7620 /42.0	18125 /100	10505 /58.0	7620 /42.0	12.32
Cherikov district	1020,2	13152 /100	8144 /61.9	5008 /38.1	13152 /100	8144 /61.9	5008 /38.1	12.89
Shklov district	1334,2	27332 /100	16300 /59.6	11032 /40.4	27332 /100	16300 /59.6	11032 /40.4	20.49
Total for the region	26523,88	1045360/100	843800 /80.8	201560 /19.2	1023329	831845 /81.3	191484 /18.7	38.58
Gomel region								
Gomel	135,3	535693 /100	535693 /100	–	535693 /100	535693 /100	–	3959.30
Buda-Koshelev district	1594,5	29530 /100	10965 /37,1	18563 /62.9	29530 /100	10965 /37.1	18565 /62.9	18.52
Vetka district	1558,6	17838 /100	8505 /47,7	9333 /52.3	17838 /100	8505 /47.7	9333 /52.3	11.44
Gomel district	1955,8	68306 /100	2534 /3,7	65772 /96.3	68306 /100	2534 /3.7	65772 /96.3	34.92
Dobrush district	1452,7	36110 /100	21432 /59,4	14678 /40.6	36110 /100	21432 /59.4	14678 /40.6	24.86
Zhlobin district	2110,8	102017 /100	77425 /75,9	24592 /24.1	102017 /100	77425 /75.9	24592 /24.1	48.33
Loev district	679,58	11799 /100	6698 /56,8	5101 /43.2	7669 /65	4354 /56.8	3315 /43.2	11.29
Korma district	949,2	13213 /100	7624 /57,7	5598 /42.3	13213 /100	7624 /57.7	5589 / 42.3	13.92
Rechitsa district	2171,2	97979 /100	71506 /73,0	26473 /27.0	78383 /80	57209 /73.0	21174 / 27.0	36.10
Rogachev district	2067,0	56768 /100	34809 /61,3	21959 /38.7	56768 /100	34809 /61.3	21959 / 38.7	27.46
Svetlogorsk district	949,95	83200 /100	71264 /85,7	11936 /14.3	41600 /50	35632 /85.7	5968 /14.3	43.79
Chechersk district	1229,9	14308 /100	8445 /59,0	5863 /41.0	14308 /100	8445 /59.0	5863 /41.0	11.63
Bragin district	588,15	11887 /100	5485 /46,1	6402 /53.9	3566 /30	1646 /46.1	1920 /53.9	6.06
Total for the region	17442,68	1078648/100	862385 /80,0	216261 /20.0	1005001	806273 / 80.2	198728 /19.8	57.62
Minsk region								
Minsk	307,0	1982444 /100	1982444 /100	–	1982444 /100	1982444 /100	–	6457.47

District	Basin area, km^2	The population in the region, thousand people/%			Population in the basin, thousand people, total /%,			Population density, people/km^2
		total	urban	rural	total	urban	rural	
Zhodino	22,0	64559 /100	64559 /100	–	64559 /100	64559 /100	–	2934.50
Berezino district	1940,3	22015 /100	11672 /53,0	10343 /47.0	22015 /100	11672 /53.0	10343 /47.0	11.35
Borisov district	2927,85	180639 /100	143051 /79,2	37588 /20.8	177026 /98	140205 /79.2	36821 /20.8	60.46
Krupki district	1390,16	22557 /100	10962/48,6	11595/51.4	14662 /65	7125 /48.6	7537 /51.4	10.55
Logoisk district	946,00	35631 /100	18933 /53,1	16698 /46.9	14252 /40	7573 /53.1	6679 /46.9	15.07
Minsk district	1360,52	215404 /100	24207 /11,2	191197 /88.8	150783 /70	16945 /11.2	133838 /88.8	110.83
Puhovichi district	1221,10	65113 /100	29986 /46,1	35127 /53.9	32557 /50	14993 /46.1	17564 /53.9	26.66
Smolevichi district	1394,10	46225 /100	17927 /38,8	28298 /61.2	46225 /100	17927 /38.8	28298 /61.2	33.16
Cherven district	1630,40	31870 /100	15115/47,3	16755 /52.7	31870 /100	15115 /47.3	16755 /52.7	19.55
Total for the region	13139,42	2666457/100	2190110 /82,1	347601 /17.9	2536393	2278558 /84.9	257835 /15.1	193.04
Total (for the basin)	63723,42	5054344	4212341 /80,8	842003 / 19.2	4786301	4076267 / 79.2	710034 /20.8	75.11

According to the 2009 census, more than 80% of Belarusian people live in the Republic of Belarus. 8.2% of Russians, 3,1% of Polish, 1.7% of Ukrainians, 0.13% of Jewish and 3.5% of other nationalities live in Belarus. Mainly Belarusians, Russians and Ukrainians live within the Dnieper river basin (table 1.3). The main religion professed by the inhabitants of the Dnieper basin is orthodoxy, in the western part of the basis there are a lot of Catholics (Minsk, Minsk region).

Map of population changes is given in Appendix B (figure 22).

Currently, there is a significant migration of the population both inside the republic and outside.

Table 1.3 – The ethnic composition of the population in the Dnieper Basin

Region	Ethnic composition of the population, %					
	Belarusian	Russian	Ukrainian	Jewish	Polish	others*
Gomel region	88.2	7.71	2.15	0.16	0.14	1.64
Vitebsk region	85.14	10.15	1.18	0.17	0.91	2.45
Minsk region	88.5	7.14	1.25	0.05	1.26	1.8
Mogilev region	88.7	7.85	1.19	0.13	0.16	1.97
Total for the Republic of Belarus	83.4	8.2	1.7	0.1	3.1	3.5

* The Armenians, Tatars, Gypsies, Azerbaijanis, Moldovans, Lithuanians, Germans, Georgians, Latvians and other nationalities also live here.

It should be noted that the territory of the Dnieper Basin was the most affected by the Chernobyl nuclear power plant accident in April 1986 (about 1/3 of the territory was contaminated by cesium-137 – over 1 Ci/km^2, and small areas of Vetka, Dobrush and Bragin districts are also contaminated with strontium-90).

According to the Belarusian State Statistics Committee as of January 1, 2013, about 2394 settlements are located in the zone of radioactive contamination; people live in 2352 settlements. Periodic radiation monitoring is carried out within 1864 settlements. The citizens of 470 settlements have the right to resettle and 18 settlements have the right for the subsequent resettlement.

1141,8 thousand people live in the zone of radioactive contamination, including 216,9 thousand children under 17 years of age, 1024,3 thousand people in the zone with periodic radiation monitoring (189,8 thousand of children). 115.6 thousand people live in settlements with the right of resettlement, including 26,6 thousand children. 1,9 thousand people live in the areas with the right of subsequent resettlement including 0,5 thousand children.

Within the territory of the Dnieper Basin the greatest radionuclide contamination (cesium-137 and strontium-90) is observed in Kostyukovichi, Krasnopolle, Slavgorod districts of the Mogilev region, and Chechersk, Vetka, Dobrush and Bragin districts of the Gomel region.

4.2.2 Agriculture (plant production, animal husbandry)

The agricultural and industrial complex of the republic in the Dnieper river basin is represented by agricultural organizations such as unitary enterprises and branches (structural subdivisions) of service and industrial enterprises which attached agricultural organizations, and farm (peasant) farms, processing and servicing organizations of various forms of ownership. The agro-industrial complex is able to meet the population's requirements for essential food products and provide the processing industry with raw materials.

Agriculture in the Dnieper river basin is focused on the cultivation of traditional crops for temperate latitudes.

Plant industry is represented by cereal crops. These are mainly barley, rye, wheat, potatoes, fodder crops. Flax cultivation and production is highly developed.

Farm industry is mainly characterized by raising cattle for the production of milk and meat, as well as pigs and poultry.

According to the National State Statistical Committee of the Republic of Belarus, within the Dnieper basin in Belarus, there has been a steady increase in agricultural production from 2000 to 2017 with a percentage increase in almost every subsequent year relative to the previous one. The final indices of agricultural production within farms of all categories in 2017 in comparison with 2000 were[1]: the Vitebsk region – 158.7%; the Mogilev region – 190.4%; the Gomel region –215.0%; the Minsk region – 222.5%.

According to the data of the National Statistical Committee of the Republic of Belarus for 2016, *the production of agricultural products in the Vitebsk region* is concentrated within 255 agricultural organizations and in 312 peasant (farmer) farms.

[1] http://www.belstat.gov.by/ofitsialnaya-statistika/realny-sector-ekonomiki/selskoe-hozyaistvo/osnovnye-pokazateli-za-period-s-__-po-____gody_6/indeksy-obema-produktsii-selskogo-hozyaistva-v-hozyaistvah-vseh-kategorii-po-oblastyam/ - the information by National Statistical Committee of the Republic of Belarus

The area of agricultural land in the Vitebsk region is 1561.5 thousand hectares (39% of the region's territory). The region produced 970 kg of grain, 661 kg of potatoes, 128 kg of meat and 772 kg of milk per caput.

The Minsk region is the largest agricultural region in Belarus. In most areas meat and dairy farming, poultry farming, grain production, potato growing and flax cultivation is highly developed. Beet is developed in the south-west of the region. Agricultural enterprises near large cities specialize in growing vegetables and fruits.

The production of agricultural products in the Minsk region is concentrated within 386 agricultural organizations and in 670 peasant (farm) farms.

The Minsk region specializes in the production of milk, meat, grain, potatoes, sugar beet, vegetables and annually produces more than a quarter of the country's gross agricultural output.

The lands for agricultural use occupies 1598.4 thousand hectares, including plough land with 1077.1 thousand hectares, meadow lands with 510.8 thousand hectares, and gardens with 10.4 thousand hectares. Agricultural organizations of the region occupy 21% of the area of agricultural land in the republic. In terms of one agricultural organization, agricultural lands occupy 3,649 hectares, where 2448 hectares are occupied by plough land. The plowing of lands is 67%. The fertility rate of agricultural land is 30.4. The fertility rate of the plow land is 32.9. And the fertility rate of the forage land reaches 26.3.

In the Minsk region agricultural and other organizations produce about 26.7% of the gross agricultural output per year, including 27.1% of the milk product, 24.9% of meat, 27.0% of crop, 33,5% of the sugar beets, 29.6% of potato, 36.3% of vegetables. The share of crop production in the volume of gross agricultural output is 39.1%. The share of animal production in the volume of gross agricultural output is 60.9%.

The area of agricultural land in the Minsk region is 1863.9 thousand hectares (46.4% of the region). In the region 645 kg of grain, 676 kg of potatoes, 493 kg of sugar beet, 76 kg of meat and 470 kg of milk is produced per capita.

The production of agricultural products in the Mogilev region is concentrated within 193 agricultural organizations and in 300 peasant (farmer) farms.

In the Mogilev region the area of agricultural land is 1391.5 thousand hectares (47.9% of the region's territory). In the region 1141 kg of grain, 781 kg of potato, 101 kg of meat and 717 kg of milk is produced per capita.

The production of agricultural products in the Gomel region is concentrated within 220 agricultural enterprises and 396 farm (peasant) farms. The main agricultural industries are meat and dairy cattle breeding, vegetable growing and potato growing, as well as flax cultivation (in the eastern part of the region).

In the Gomel region the area of agricultural land is 1381.7 thousand hectares (34.2% of the region's territory). Cereals are cultivated everywhere in the region (49% of all sown areas). About 12% of the acreage is occupied by potato. About 4.2% of acreage is occupied by vegetables and technical crops, and 34% is occupied by feeding crops.

In the region 790 kg of grain, 714 kg of potatoes, 89 kg of meat and 641 kg of milk is produced per capita.

4.2.3 Fish breeding

More than 480 ponds with a total area of 6695.7 hectares are located within the Dnieper basin. Thus 245 ponds have a total area less than 10 hectares each and 13 ponds reach over 50 hectares each.

The Decree of the Ministry of Agriculture and Food of the Republic of Belarus of June 18, 2014 No.29 approved the Republican integrated scheme for allocation of fishing areas. Regional Executive Committees

provide fishing areas for rent in accordance with the Republican Integrated Scheme for the allocation of fishing grounds. It is approved by the Ministry of Agriculture and Food in agreement with the State Inspectorate for the Protection of Fauna and Flora under the President of the Republic of Belarus (Paragraph 9 of the Rules for Fish Farming and Fisheries is approved by Decree of the President of the Republic of Belarus of December 8, 2005 No.580).

The list of surface water bodies in the Pripyat river basin, leased for fish farming and fisheries for individual water use, are given in Tables 15 and 16.

The State Program for the Development of Agrarian Business in the Republic of Belarus for 2016–2020 a number of activities is mentioned. The main activities are:

- technical re-equipment and modernization of fish-breeding organizations;
- the production of pond and lake-river fish, as well as valuable fish species, the formation of a pedigree base of valuable fish species (sturgeon, salmon, catfish and other valuable fish species) in breeding farms;
- reaching the estimated capacity of three industrial fish breeding complexes for the cultivation of valuable fish species (in Belynichi, Bykhov and Kostyukovichi districts of the Mogilev region), put into production within the framework of the State Program for the Development of Fishery Activities for 2011–2015;
- finishing the construction of an industrial fish breeding complex for the cultivation of valuable fish species in the Nesvizh district of the Minsk region;
- stocking of fishing areas with rare with valuable fish species;
- restoration of natural breeding grounds and creation of artificial spawning grounds;
- reproduction and reintroduction of rare and valuable fish species in order to get fish seed of rare and valuable fish species (whitefish, pikeperch, pike, salmon, sturgeon and others).

Economically significant fish species in the Dnieper basin are produced at specialized fishery enterprises. The main fishery enterprises are OJSC “Rybkhoz Volma” (Cherven district), MIUE “Trout farm Lohva” (Kostyukovichi district), OJSC “Rybhoz Svisloch” (Osipovichi district).

The list of surface water bodies, leased for fish farming in 2017, is given in Table 16 of Appendix A.

There are no specially protected areas within the water body areas connected with permanent restrictions on recreational fishing due to the presence of economically important fish species and (or) unique mollusks in these water bodies.

4.2.4 Forestry

Within the Dnieper basin, as well as throughout the territory of Belarus, the Ministry of Forestry of the Republic of Belarus coordinates the activities of other republican government bodies, local executive and administrative bodies, legal entities that control forestry, regardless of the form of ownership, in the use, preservation, protection state forest fund and reproduction of forests. The main legal entities include the state forestry institutions of the Ministry of Forestry such as 46 forestry enterprises by the number of administrative districts in the Dnieper Basin.

The main woodworking enterprise in the Dnieper basin is OJSC "Gomeldrev", which produces sets of cabinet-work furniture, office and cushioned furniture, hallways, tables, bedside tables, chairs, armchairs, matches, plywood.

4.2.5 Manufacturing

Manufacturing is the most important branch of the national economy, which has a significant impact on the level of development of the society productivity. It consists of two branches such as mining and processing.

The Dnieper Basin territory has a significant industrial potential. And it is one of the highly developed industrial regions of Belarus.

The largest industrial centers of the republic are located in the Dnieper river basin. They are Minsk, Zhodino, Gomel, Bobruisk, Mogilev, Zhlobin, Shklov, Svetlogorsk, Dobrush, Orsha centers and others.

In general, in the Dnieper basin, according to the data of the National Statistical Committee of the Republic of Belarus, an increase in industrial production has been observed over the past 7 years (with the exception of the city of Minsk). So, the industrial production index in comparable prices in 2017 in comparison with 2010 has the following values: the Vitebsk region – 103.4%; the Mogilev region – 101.3%; the Gomel region – 109.8%; the Minsk region – 154.5%; Minsk city – 86.1%.

Enterprises of the Vitebsk region produce 17.5% of the republican volume of industrial output. The Vitebsk region specializes in the production of electricity, refined products, metal cutting machines, polyethylene, and limestone and dolomite flour for liming acidic soils, televisions, linen fabrics, shoes. Vitebsk region exports products for 81 countries of the world. The most important types of exported products are oil products, meat and dairy products, synthetic fibers and threads, ethylene polymers, fiberglass, footwear, insulated wires and cables.

The Minsk region is one of the most economically developed regions of the country.

The manufacturing of the Minsk region has a developed industry structure and close industrial communication with the industrial complex in Minsk.

The structure of manufacturing industries in the Minsk region:

- food industry – 26.5%;
- chemicals and petrochemical industry – 25.1%;
- machinery and metal working industry – 22.9%;
- forestry, woodworking and paper industry – 6.3%;
- building material industry – 5.3%;
- consumer industry – 3.2%.

Over 400 enterprises operate in the region.

A significant part of industry is concentrated in two cities of the Dnieper Basin (the percentage of industry in the region is indicated in parentheses): Borisov (19.8%); Zhodino (13.95%).

The largest enterprise of the chemical and petrochemical industry is the Republican Unitary Enterprise "Production Association "Belaruskali" in Soligorsk. In the field of machine building and metalworking the largest enterprise is the Republican Unitary Enterprise "Belarusian Automobile Plant", specializing in the production of large-load dump trucks intended for quarrying and used in the construction of hydraulic buildings.

Among the leaders of the food industry are enterprises that produce bakery products, meat processing plants, and a cheese-making plant.

The enterprises of the Minsk region produce 15.2% of the republican volume of industrial output. The region specializes in the production of potassium fertilizers, tiles, chrome leather goods, knitted goods, pasta, sugar, mineral waters. The Minsk region realizes an active foreign trade and occupies one of the leading places among the regions of the republic. 12% of the country's foreign trade turnovers accrue to the Minsk region.

Minsk is the largest industrial center of the republic. Enterprises of Minsk produce 19.7% of the republican volume of industrial output. The city specializes in the production of trucks, tractors, buses, trolleybuses, motorcycles, bicycles, power transformers, household refrigerators and freezers, rolling bearings, woolen fabrics.

The ratio of Minsk in the foreign trade turnover of the republic is more than 40%. Export-import operations are carried out with 194 countries. Minsk organizations promote the products produced both in the

city and in other regions of Belarus to the foreign market. First of all, these are oil products, tractors and truck tractors, trucks, refrigerators and freezers.

At present, in the Mogilev region there are about 200 industrial enterprises, associations, joint-stock companies. In the structure of the industrial complex, chemistry and petrochemistry occupies 28.3%, machine building and metalworking – 15.5%, food industry – 16.8%, electric power industry – 10.4%, construction materials industry – 6.3%, consumer industry – 4.7%, timber, woodworking and pulp and paper industry – 2.9% and other industries – 15.1%.

The largest industrial centers of the region are Mogilev, Bobruisk, Krichev, Kostyukovichi, Osipovichi cities.

The enterprises of the Mogilev region produce 8.7% of the republican volume of industrial output. The region specializes in the production of elevators, automobile tires and tires for agricultural machines, woodworking machines, tractor trailers, tractor mowers, steel pipes, AC electric motors, centrifugal pumps, soft roofing materials, cement, slate, chemical fibers and threads, silk fabrics, tulle and curtain fabrics, rubber shoes.

The leading place is occupied by the chemical and petrochemical industry. The proportion of the two largest chemical companies such as OJSC “Mogilevkhimvolokno” and “Belshina” is more than 30% of the volume of all products produced in the region.

Regional organizations realize foreign economic activity. Export-import operations are carried out with 123 countries of the world. In the commodity structure of exports, tires, elevators, synthetic fibers, polyethylene terephthalate, dairy and meat products prevail.

Within the territory of the Gomel region, there are more than 300 large and medium-sized industrial enterprises. The leading branches are fuel industry, chemical, ferrous metallurgy, machine building, and oil producing, food, wood, woodworking and pulp and paper industry.

The fuel and energy complex (including Svetlogorsk, Mozyr and Gomel CHPPs, Mozyr Oil Refinery, Belorusneft Production Association) come first in the industry structure of industry in the Gomel Region.

Enterprises of the Gomel region produce 21.8% of the republican volume of industrial output. The region specializes in the production of oil, natural gas, the production of rolled ferrous metals, steel, motor gasoline, diesel fuel, heating oil, phosphate fertilizers, forage harvesters, combine harvesters, metal cutting machines, polished and window glass, linoleum, wallpaper, student notebooks, cardboard, paper, chipboard, plywood, porcelain and earthenware. The regional organizations realize foreign economic activity. Export-import procedures is carried out with 115 countries of the world. They deal with the export of oil, ferrous metals and products from them, machines and mechanisms for harvesting and threshing crops, mineral mixed fertilizers, dairy products, plastic containers, salt, polished glass and other products.

The main types of products of the leading industrial enterprises of the Gomel Region, located in the Dnieper Basin, are the following:

- Belarusian Steel Woks conducts the manufacture of metal cord, cast, tubular and rolled bars, and steel and reinforcement low-carbon wire.
- Production association "Belorusneft" carry out oil and gas production, exploration of oil fields, diversified production of consumer goods.
- Gomel Chemical Plant produces sulfuric acid, amorphos, nitrogen-phosphorus-potassium fertilizers, ammoniated superphosphate sodium sulfite, aluminum fluoride, cryolite.
- Svetlogorsk Production Assosiation "Himvolokno" produces chemical fibers and threads, viscose tow, polypropylene bags, polyethylene film, heat-resistant carbon materials.
- OJSC "Gomelsteklo" produces polished sheet glass (float-process glass), glued insulated glass for construction purposes made using TPS technology, safety glass for ground transport vehicles, hardened glass for building, glassware for furniture, hardened glass products for gas and electric ovens plates, shelf-glass for household refrigerators, heat-insulating foamed glass blocks, safety glass for ground transportation (multilayered) - triplex.

- OJSC “Gomeldrev” produces cabinet, office and upholstered furniture, hallways, tables, bedside tables, chairs, armchairs, matches, plywood.
- OJSC Gomel industrial and trading company "8 Marta" produces knitwear and hosiery.
- Gomel Machine-Tool Plant named after Kirov produces metal-cutting and non-metal cutting machine tools (including CNC), specialized machines, cantilever-milling machines, umbrellas, washing machines, household centrifuges, microwave ovens.
- Production Association "Gomselmash" produces self-propelled forage combine harvesters, beet and grain harvesters, trailers-containers, collectors, reapers.
- OJSC “Gomelstroymaterialy” produces wall materials, silicate bricks, mineral wool boards, linoleum, vorsanit, isoplen.
- OJSC "Spartak" produces caramel, biscuits, waffles, chocolate, and sweets.
- OJSC Gomel Fat Plant produces vegetable oil, mayonnaise, margarine products, household and toilet soap.
- Gomel Production Association "Kristall" produces abrasive diamond-set tools, synthetic diamond powders, jewelry, silverware and cupronickel dishes.
- OJSC "Gomeloboi" produces wallpaper with engraved printing, photosensitive and writing paper, printed forms.
- CJSC "Farfor" produces various porcelain and faience products.

The Republican Unitary Operational-Construction Enterprise "Dnieper-Bug Waterway" (RUESP "Dneprobugvodput", Pinsk) of the Ministry of Transport and Communications of the Republic of Belarus is the main organization in the field of operation, construction and reconstruction of water transport systems and hydraulic structures, including dredging on rivers of Belarus, including in the Dnieper Basin.

4.2.6 Hydraulic power industry

At present, the hydropower potential in the Dnieper basin is not greatly used.

The power of the largest hydroelectric power station in Belarus in the Dnieper Basin is 2.175 MWth. It is called Osipovichi HPP, which was put into operation in 1953. The power of the Chigirin HPP in the Drut River is 1.5 MWth.

The basin area is flat, which predetermines the development of hydropower using the potential of low-pressure streams. The greatest potential of hydropower engineering in the Dnieper Basin is concentrated in the Mogilev Region directly on the Dnieper River itself.

In 2018, within the framework of the subprogram II of the State Scientific-Technical Program (SSTP) "Environmental Management and Environmental Risks" of RUE "CRICUWR", the activities for the assessment of the hydropower potential of the middle and small rivers of the Dnieper river basin were started.

4.2.7 Accumulation of waste

In 2017 the volume of waste production in the Republic of Belarus was 55.5 million tons. The most significant volume of large-tonnage waste generation is due to halite waste and slime of halite clay-salt reaching 37.3 million tons; and waste of phosphogypsum reaching 713.85 thousand tons.

The formation of production wastes on the territory of Belarus is rough. Without including galite waste, clay-salt slimes and phosphogypsum, 22.48% of waste is generated at enterprises located in the Mogilev region; 19.57% in Minsk; 17.94% in the city of Minsk; 13.72% in the Gomel region; 13.41% in Grodno; 8.5% in Brest; 4.38% in the Vitebsk region.

At the same time, the level of use of industrial waste (excluding halite waste and clay-salt slurries) is about 90%.

It should be noted that in 2017 the enterprises of the republic carried out more than 1400 activities, which are aimed at reducing the volume of formation and (or) accumulation of production wastes.

The Ministry of Natural Resources coordinates the implementation of the provisions of the Stockholm convention on persistent organic pollutants and the Basel Convention on the control of transboundary movements of hazardous wastes and their disposal in the Republic of Belarus.

Landfills for the storage and disposal of municipal solid wastes are concentrated in the district centers of the Dnieper Basin (46 administrative districts) and are located outside the water protection zones of water bodies.

In accordance with the Water Code, water protection zones are established to prevent pollution, clogging and depletion of water bodies, as well as to preserve the habitat of wildlife and vegetation objects in the territories adjacent to water bodies. Within the water protection zones coastal areas of strict security regime are allocated. In the water protection zone of rivers and reservoirs, a special regime for economic and other activities is established. Projects on water protection zones and coastal areas of large and middle rivers of the Republic of Belarus were developed by RUE "CRICUWR" in 2002–2005 on maps of scale 1:50 000 and approved by regional executive committees.

Information on objects that have a harmful effect on water quality and located on the territories of water protection zones and coastal strips of water bodies in the Dnieper river basin will be given in the table 20 of the Appendix A.

4.2.8 Shipping industry

Through the territory of Belarus the section of the international waterway E-40 passes, which connects the Black and Baltic Seas (the Visla River from Gdansk to Warsaw – Brest – Pinsk – the Dnieper River through Kiev to Kherson).

The Dnieper, Sozh, and Berezina rivers are part of the inland waterways of the Republic of Belarus. There are 4 river ports in the Dnieper river basin (Bobruisk, Gomel, Mogilev, Rechitsa) and 2 waterway enterprises (Gomel, Bobruisk).

Information on surface water bodies related to inland waterways open to navigation is given in table 17 of Appendix A.

Map of waterway transport is given in Appendix B (figure 21).

4.2.9 Tourism and recreational use of water bodies

Surface water bodies in the Dnieper Basin have significant value and are an important resource of tourist and excursion programs. However, at present the proportion of water tourism in the structure of the national tourism product of Belarus (as an independent element, and complementing other directions such as ecological, rural, cognitive, adventure tourism) remains not very prominent.

Water area is a favorite place for recreation, sports and health improvement of people. Almost all recreational facilities and buildings are located either on the banks of water bodies, or near them.

In recent years, the scope of recreational water activities is constantly growing, which is connected with the increasing number of urban population and the improvement of transport communications.

The main factor why a reservoir and watercourses can be considered as a recreational facility is the population's need for their availability. In this regard, it is accepted that objects of recreation are those water bodies and watercourses located in cities and populated areas with a population of 50 thousand people or more. Taking into account the above criteria and requirements, the analysis of various types of water bodies

that can be used for recreational purposes has been made. And a map of recreational use of water bodies has been completed. The list of reservoirs located in the Dnieper river basin and indication of their recreational use will are given in the Table 3 of the Appendix A.

At present, the reservoirs do not have a developed infrastructure of institutions and recreation areas. They are mainly used for unorganized short-term rest. Moreover, people intensively use water bodies which are located in 1 hour away from large settlements.

Citizens, as a rule, recreate near rivers. The zone of active recreation, as a rule, is concentrated in 1-1,5-hour availability, with the main visitation during the active summer recreational season.

In the current radiation situation, the Dnieper river has recreational significance only in its upper reaches, where large industrial centers are located such as Orsha and Mogilev cities. The population of these cities can recreate on beaches with a capacity of up to 60 thousand people. However, morphometric features of the structure of the valley of the Dnieper river in the upper reaches (high right bank, often steep, and in some places abrupt) require additional activities to organize the way down to the water.

The largest consumers of recreational resources such as Borisov, Bobruisk and Svetlogorsk are located within the picturesque banks of the Berezina river. Borisov has 4 sites, which can hold up to 25 thousand people at a time. On the territory of the Mogilev and Gomel regions, the banks of the river are steeper, 1-2 m high, sandy and loamy. Slopes are covered by willow and alder bushes in some areas. Here up to 90 thousand people can resort on the beaches.

On the Svisloch River, taking into account the morphometric structure of the river valley, marked by swampiness in the lower reaches, as well as the ecological state of the river below Minsk, it is possible to organize beaches with a capacity of up to 15 thousand people in 4 areas.

According to the temperature regime, the duration of a comfortable regime of recreation in the basin of the Dnieper river reaches 170 days.

4.2.10 Linear infrastructure

Transport and traffic network

Transport complex of the territory has sufficient capacity to meet the needs of enterprises and the population for transportation and services.

Important transport routes pass through the Gomel region. Large railway junctions are the Gomel, Zhlobin, Kalinkovichi cities. Gomel is located at the intersection of roads E 95 Odessa –Kiev – St. Petersburg, Bahmach – Vilnius, M10 Bryansk - Brest.

Highway E 95 St. Petersburg – Kiev – Odessa, Bryansk – Kobrin, M5 Gomel – Minsk, Gomel – Mozyr are connected by bus to all regional centers of the region.

It is possible to make flights to the cities of the republic and foreign countries from Gomel. There is an airport in Gomel.

City public transport in the Mogilev region is represented by buses, trolleybuses, and route taxis.

Trolleybuses operate in Mogilev, as well as in the district center of Bobruisk. Bus traffic is opened in 17 cities. These are Mogilev, Bobruisk, Gorki, Osipovichi, Krichev, Shklov, Bykhov, Kostyukovichi, Klimovichi, Mstislavl, Chausy, Belynichi, Cherikov, Slavgorod, Krugloe, Klichev cities.

The main means of transport in the Mogilev region is railway. The main lines are Leningrad – Odessa, Orsha – Unecha, Bakhmach – Bobruisk – Minsk – Vilnius, Krichev – Mogilev –Osipovichi – Baranovichi. Large railway junctions are Mogilev, Bobruisk, Osipovichi, Krichev.

The RUE "Mogilev branch of the Belarusian Railways" is a complex multi-profile enterprise that serves 30,000 km^2 of the territory of the Mogilev region. The railway branch also includes 5 districts of the Minsk region, 3 districts of the Gomel region and 1 district of the Vitebsk region.

The company manages more than 1180 km of main railway tracks, 495 km of station and 231 km of local railway tracks. Four track maintenance departments such as Krichev, Mogilev, Osipovichi and Bobruisk take the direct responsibility for these important parameters.

Main highways are St.Petersburg – Odessa, Mogilev – Minsk, Mogilev – Bobruisk, Bobruisk – Minsk.

To service the population of the region, the regular traffic of 387 suburban, 136 urban, 79 intercity and 6 international routes are organized, the length of which is 1470.8 km in the city, 13205.6 km in the urban area, and 8723.7 km in the interurban one. Services are provided for passengers within 21 passenger terminals.

Mogilev is connected by airlines with Moscow, Minsk and other cities, as well as with regional centers. The oil pipeline "Unecha – Polotsk" passes through the territory of the region.

The Minsk region is located at the intersection of the main transport routes linking Western Europe and the East, the regions of the Black Sea coast and the Baltic countries. An extensive network of highways has been created in the region. The railway network of the region connects Russia and Europe, the Baltic countries and the southern states of the CIS.

Minsk is connected by regular air communication with capitals and large industrial and resort cities of the CIS countries, capitals, large industrial and tourist centers of the states of Western Europe, the Middle East.

Main petroleum pipelines and product pipelines

In the single transport system, pipeline transport in Belarus is represented by four main pipelines, two of which are located in the Dnieper basin:

- *Pipeline Druzhba «Unecha-Polotsk-Ventspils»* (2 branch lines) is the main oil pipeline that transports Russian oil from the West Siberian region, Tatarstan and the Volga region to Belarus and the Baltic countries. The length of the pipeline in Belarus is 492.5 km, diameter is 1067 mm, and throughput capacity is 40 million tons of oil per year. The operating organization is "Polotsktransneft Druzhba". The pipeline is located in the territory of Kostyukovichi, Klimovichi, Krichev, Mstislavl, Dribin, Shklov, Horki districts of Mogilev region, and Orsha, Senno, Beshenkovichi, Ushachi, Polotsk, Miory, Braslav districts of Vitebsk region.

- *Pipeline Druzhba "Unecha-Mozyr-Brody"* is the main oil pipeline transporting Belarusian oil and also the transit of Russian and Kazakh oil to the countries of Central Europe and Ukraine. The length of the pipeline in Belarus is 215 km, the diameter is 1200 mm (the Unecha-Mozyr branch), 800 mm (Mozyr-Brody branch), the throughput capacity is 90 million tons of oil per year (Unecha-Mozyr branch), 15 million tons of oil in year (Mozyr-Brody branch). The operating organization is OJSC "Gomeltransneft Druzhba". The pipeline is located on the territory of Dobrush, Gomel, Rechitsa, Kalinkovichi, Mozyr and Yelsk districts of the Gomel region.

4.3 Water resources

4.3.1 Hydrographic network

General description

River system of the Dnieper is tree-structured, type III, well developed. It has over 17,000 stream flows over 1 km in length with a total length of about 88380 km. About 9,000 km (10%) are artificial water bodies such as channels and ditches of water and drainage systems, which are mostly concentrated within the Polesye territory.

The great majority of the hydrographic network includes small stream flows, with a length of over 100 km. There are only 30 rivers, and this is 9% of the total length of the river system. The density of the river network along the Dnieper River in the territory of Belarus reaches: in Orsha – 0.47 km/km2, below the mouth of the Drut River – 0.45 km/km2, below the mouth of the Berezina River – 0.41 km/km2, Rechitsa – 0.39 km/km2, below the mouth of the Sozh River – 0.39 km/km2. On the average the density of the river network within the territory of Belarus is 0.39 km/km2.

Climate features defined the hydrological regime of the Dnieper and its tributaries. River basins have mixed feeding. The main source of feeding is snow water, which forms a significant part of the runoff (50%), as well as underground water (27%) and rainwater (23%). The role of snow water gradually increases downstream of the Dnieper River. Spring flood of the Dnieper River is characterized by one wave, less often by two waves. 68% of the annual runoff is in the spring flood period, 28% is for the summer, and 4% for the winter runoff. To the south direction, the percentage of spring runoff is reduced to 57%, summer-autumn and winter runoff is increased to 30% and 13%, respectively. A stable freeze-up is formed in the end of November or early December. In particular years the maximum thickness of ice reaches 60–80 cm. The river is opened at the end of March and beginning of April, the spring ice drift lasts from 4 to 7 days. The average water temperature in the summer reaches 19-22 °C.

Table 3 of Appendix A shows the main characteristics of 92 reservoirs within the river basin.

Table 4 of Appendix A shows the characteristics of 162 river water bodies in the Dnieper basin.

Surface water bodies in the Dnieper Basin were defined in accordance with methodology of the identification delineation and classification of surface water bodies. These methodologies are developed by the EPIRB project2.

Within the Dnieper river basin, the corresponding surface water bodies were identified with differentiation according to the developed typology. These types have been identified with the use of the system A of the Water Framework Directive (WFD) and Guideline No.2 "Identification of water bodies".

To establish and identify surface water bodies, all rivers with a river basin area of more than 100 km2 and lakes with a surface area of more than 1 km2 were under consideration2. Table 4.1 of Appendix A shows the criteria used to identify river water bodies.

After the identification of water bodies, their typology (typification) was carried out. The typology methodology is based on the determination of similar characteristics of a water body in accordance with morphometric, hydrological and hydrogeological characteristics. Table 4.2 of Appendix A shows the criteria used in the typology of river water bodies.

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2 Guideline № 2 «Identification of water bodies» in WFD

Table 4.3 of Appendix A shows the results of the identification of river water bodies with due regard to their typology.

The hydrogeological characteristics, which are used for the typification of surface water bodies, represent the type of predominating underlying geological rocks.

In accordance with the requirements of the WFD, depending on the predominating rock composition, drainage basins are formed. They are composed of limestones, silicate and organic rocks. Catchment basins in the Dnieper Basin are the first two types. Geological factors determine a number of features of the river basin.

In the result of the typification of identified surface water bodies, it was determined that all the rivers of the Belarusian part of the Dnieper Basin belong to the same eco-region (No.16 East-European Plain). And in accordance with geological factors, height above sea level and the size of the catchment basin these rivers belong to 9 types.

108 river water bodies and 9 lake water bodies were identified within the Belarusian part of the Dnieper Basin.

The map-scheme №3 of Appendix A shows the results of identification of surface water bodies in the Dnieper basin within Belarus.

1.2.1.2 Rivers

The main characteristics of river water bodies in the Dnieper basin are shown in Table 4 of Appendix A.

Including the Dnieper River which has the following main tributaries:

The Berezina River — is one of the main tributaries of the Dnieper River. It heads 1.0 km away to the south-west from the Dokshitsi in the Vitebsk region, then flows through the Minsk, Mogilev and Gomel regions, flows into the Dnieper River in the right between Zhlobin and Rechitsa cities, 5.0 km southeast away from village Horval. The length of the river is 561 km; the catchment area is 24500 km2.

There are following main right tributaries of the Berezina River from the upper reaches to the mouth: the Gaina River (93 km), the Usha River (89 km), the Svisloch River (257 km). The left tributaries are the Bobr River (124 km), the Kleva River (80 km), the Olsa River (92 km), the Ola River (116 km).

The Berezina river basin is located within the southeast slope of the Belorussian ridge, which is a watershed between the Baltic and Black Seas. In the north, it borders the Western Dvina river basin. In the west, east and south it borders with the basins of the Ptich, Drut and Pripyat rivers. The greatest length of the basin is 320 km; the average width is 77 km.

In its upper stream, the Berezina River crosses the Upper Berezina lowland with rising moraine and dune hills with the height of 10–15 m. A vast part of the basin is occupied by the flat-wavy Central-Berezin plain (with average height of 150–180 m), where areas of moraine ridges 20–30 m in height can be found.

In the lower stream, the Central Berezina plain runs into the swampy lowland of the Gomel Polesye (with average height of 140–160 m) with small sandy elevations and shallow flowing hollows. Here the lowest basin area with 118 m above sea level is located. The most elevated northwestern part of the catchment area is on the eastern slopes of the heavily disjointed Minsk hill with the relative heights of separate hills up to 80–100 m.

A large part of the basin (about 35%) is occupied by forest massifs. Large forest areas are located in the upper part of the catchment area (Berezinsky Biosphere Reserve), in the basins of the rivers Gaina, Olsa, Ola and in the lower streams of the Svisloch River. Pine, spruce is prevailing. Oak forests and aspen-birch

groves are often found in the valleys. Lake percentage of the catchment area is about 1%. The largest lake, which is located in the basin, is the Palik Lake. Among artificial reservoirs one can outline Zaslavskoe reservoir, a cascade of reservoirs such as Krinitsa, Drozdy, Chizhovskoe and Osipovichi reservoir.

The Berezina River freezes in the first half of December and opens in late March. The maximum ice thickness is 60 cm. The spring ice drift lasts 4–7 days. The peculiarity of the regime is high floods in the end of autumn with their recession during the freeze-up period.

Within the catchment area melioration works were carried out. As of 01.01.2006, about 16% of the basin area was meliorated; about 15700 km of open drainage channel network was put into operation.

The most vulnerable to ameliorative reforms were the catchment areas of the following tributaries: the Ponya (29%), the Plissa (27%), the Ola (18%), the Sved (30%), the Vedrich (25%) rivers.

The river bed is wandering, freely meandering. Depths range from 1.5 to 3 m, reaching 5–7 m on the reach. Up to the Lake Medzozol, the river bed is strongly overgrown with aquatic vegetation, below the village Brod the aquatic vegetation is spread only within the coasts. The banks are steep, with the height of 1–2 m.

The river regime was studied within 16 posts. The posts near Borisov, Berezino, Bobruisk and Svetlogorsk are currently in operation.

The Svisloch River is the right tributary of the Berezina River in the territory of Volozhin (starts 1.5 km southeast away from village Shapovaly), Minsk, Pukhovichi, Cherven and Osipovichi districts.

The length of the river is 257 km. Before the construction of the reservoirs Drozdy and Krinitsa the length of the river was 297 km and the catchment area was 5150 km2). The main tributaries are the Vyacha River (flows into the Zaslavl reservoir), Volma, Bolochanka (left), Titovka, Talca, Sinyaya (right). The valley is predominantly clearly defined. The width in the upper stream is 400–600 m, in the middle and lower reaches is 1–-2 km. Floodplain is double-sided, alternating along the coasts, 300–500 m wide in the upper streams and 800–1000 m in the lower streams. The bed from the head of the river to the canal of the Vileyka-Minsk water system in its natural state (up to 3.5 m wide) is meandering. Downstream the bed is a part of the channel route, 20–25 m wide up to the Zaslavl reservoir. Within the boundaries of Minsk, the river forms eight bends. In the city center the banks are landscaped and decorated by concrete.

In the middle and lower streams the bed is meandering and deeply embedded. The width of the bed is 25–30 m; below the dam of the Osipovichi reservoir it is up to 50 m. The banks are steep and abrupt. The natural regime is regulated by reservoirs (Zaslavl, Krinitsa, Drozdy, Chizhovka, Osipovichi), the transfer of water from the river Viliya also affects the flow of the river.

Part of the flow from the Drozdy reservoir enters the Slepyansky water system. In the future it will fall into the Loshitsa water system, which will create a water circle with a total length of about 50 km on the territory of Minsk.

Before the construction of the Vileyka-Minsk water system, the river froze in middle of December (average duration of freeze-up is about 90 days) and it was opened in the second half of March. The duration of the flood is about 50 days. After construction, the regime of the river is poorly studied.

The average annual water discharge in the entry is about 40–50 m3/s. The catchment area is 5160 km2. In the central part of the Minsk hill and in the west of the Central Berezina Plain, artificial reservoirs such as reservoirs and fish ponds prevail. The largest reservoirs are Zaslavl, Krinitsa, Drozdy, Chizhovka, Vyacha.

The bed is freely meandering, wandering. Below the dams of the Komsomolsk Lake the bed is straightened.

The bottom is flat, sandy and sandy-muddy. The banks are steep and abrupt, often collapsed and waterlogged.

The river regime was studied within 19 posts. The posts near the Sokolovka, Khmelevka, Terebuti, Korolishchevichi villages and near Zaslavl hydroelectric complex are in the operation now.

The Volma River is a river in the Minsk, Smolevichi, Cherven and Pukhovichi districts of the Minsk region. It is the left tributary of the Svisloch River (Dnieper basin). The length is 103 km. The catchment area is 1150 km2.

The average annual water discharge in the entry is 6.8 m3/s. The average slope of the water surface is 0.5 ‰. The main tributaries are Vozha, Gat, Cervenka (left), Sloust (right).

It starts with an ameliorative channel near village Korolev Stan of the Minsk region, flows along the eastern slopes of the Minsk Hill and the Central Berezina plain. The mouth is located 1 km away from village Svetly Bor of the Pukhovichi district.

The relief of the catchment area is mainly flat. In the upper part it is fine-hilled, and 41% of the territory is covered with a mixed forest.

The valley is trapezoidal with the width of 400–600 m, in some places reaching 3 km. The slopes are flat and moderately steep. Almost the whole part of the floodplain has been drained and plowed. The river is regulated by 4 dams. The channel in the upper and middle streams in 1954, 1969, 1973, 1984 years was canalized. Its width is 3–4 m in the upper streams, 8–10 m in the middle streams and up to 40 m in the mouth. Deepening and straightening of the bed in some areas of the channel was carried out throughout the entire length in 1989. The banks are mostly steep and abrupt, with a height of 0.4 to 2 m. About 20% of the annual runoff occurs during the spring period.

The maximum flood level in the lower streams at the end of March, the average height above the low-level level is 1.4–2.2 m; the maximum height is 2.9 m. It freezes at the beginning of December, and is opened at the end of March. Spring ice drift lasts for 3–4 days.

The river feeds the ponds of the fish farm "Volma" (part of the water is discharged into the Svisloch through the ponds) in Ozerny village of the Cherven district. Carp, crucian carp, pike are grown in the fish farm "Volma". The Volma forestry hunting farm is located on the shore at 400 m away to the south of village Ivanichi of the Cherven district. The river is used as a water receiver for melioration systems.

Village Smilovichi, Petrovichi reservoir, local recreational zones "Zerkalnye ponds" and "Krasny Bereg", health-improving center "Volma" (Cherven district) are located on the Volma. Biological reserves "Yukhnovka" and "Volma" are located in the upper reaches of the watershed.

The Bobr River starts 1.5 km north-east away from Rafailovo village, Tolochin District, Vitebsk Region. It flows into the Berezina River on the left, at the 357th km from its entry, near the village Chernyaevka of the Borisov district of the Minsk region. The length of the river is 124 km; the catchment area is 2190 km2.

The main tributaries are the Nacha River which is the right-bank tributary, and the Mozha, Elenka, Plissa rivers which are the left bank tributaries.

The catchment area is asymmetric, has a complex shape, greatly expanded in the middle part. Its upper part is located on the southern slopes of the Orsha Hill, and the middle and lower parts are within the Central Berezina Plain. The forest is almost smoothly distributed throughout the catchment area. High swamps are prevailing. The most significant swamps are confined to the catchment areas of the Mozha and Nacha rivers and directly to the lower reaches of the Bobr river. There are no large lakes.

The river bed is free meandering, wandering and strongly wandering, unbranched. The banks are steep, less flat or very steep, sometimes abrupt.

It freezes in the middle of December, and it is opened in the middle of March.

The river regime was studied within 3 posts. The post near village Kuta is currently operating.

The Sozh River is the second after the Pripyat river by magnitude and water flow tributary of the Dnieper river. It heads in the territory of Russia 12.0 km south away from Smolensk, flows into the Dnieper on the left side of Loev of the Gomel region of Belarus.

The total length of the river is 648 km, of which the upper reaches with the length of 155 km belongs to the territory of Russia. The total catchment area is 42140 km2, within Belarus it reaches 21,700 km2.

There are main tributaries within Belarus as they flow into the river. The right tributary is the Pronya river (172 km).The left tributaries are the Besed river (261 km), the Iput river (437 km).

The catchment area is asymmetric, strongly developed along the left bank, pear-shaped, located on the southwestern periphery of the Smolensk Hill. It covers the Orsha-Mogilev plateau, which crosses to the eastern edge of the Pripyat Polesye in the south.

The watershed is clearly defined. It separates the left-bank tributaries of the Dnieper river in the north and north-west, and the right tributaries of the Desna river in the east.

The relief in the upper part of the basin is represented by a slightly wavy, sloping to the south plain with separate moraine ridges in the form of abrupt flat hills, whose height is from 5 to 20 m, and extensive plateau-like areas, disjointed by ravines and beams.

The river bed is a meandering. Large bend is formed by the river near Slavgorod, where there is a chain of terminal moraines on the right bank. In the upper and middle streams, their width is 15-80 m, and in the lower streams their width is 90–125 m (in some places it reaches up to 230 m). Up to Gomel there are sandy islands (30–300 m long, 10–50 m wide). Up to the entry of the Pronya river the banks are predominantly steep, lower - gently sloping, in bends and in places where the channel approaches the root bank (village Gaishin, below Slavgorod) the banks are abrupt. The width of the bed of the Sozh River in the lower streams is 230 m, the depth is up to 5–6 m, and the flow velocity is sometimes more than 1.5 m/s.

The river regime has been studied since 1896. The feeding is mixed, mostly snowy. 56% of summer-autumn and winter normal water level is for the spring flood period, and this is 54% of the annual runoff.

The rise of the water level (10–15 days in the upper streams, 20–25 days in the lower streams) begins in the third decade of March. The average height over the low water level is 4–5 m, the greatest is 6–7.5 m. Summer-autumn low-water level (May-June) is often interrupted by rain floods, which increase the water level by 1–2 m for a period of 25–35 days. Winter water levels are 10–20 cm above average summer levels, but in some years (1939), as a result of thaws in the lower streams, they rise to 2.5 m.

It freezes at the beginning of December, and it is opened at the end of March and beginning of April from the entry to the upper streams. In Belarus, the maximum ice thickness is 62-65 cm (more often in March). Spring ice drifts for 3–5 days. The average water temperature in June-August is 19–21 °C, the highest in July (28 °C).

The peculiarity of the river regime is large fluctuations in the runoff. The average annual water discharge in Slavgorod is 105 m3/s, near Gomel is 200 m3/s, at the entry is 219 m3/s. Slavgorod has the maximum water flow which is equal to 4770 m3/s (in 1907), the minimum water flow is 11.1 m3/s (in 1900). Gomel has the largest water flow which is equal to 6600 m3/s (in 1931), the smallest is 16.4 m3/s (in 1900). The average annual flow varies from 96.9 m3/s (in 1925) to 407 m3/s (in 1933).

The forest area is about 25%. The smallest forest massifs are located along the left bank of the middle and lower streams (spruce forests, pine forests).

There are few lakes in the catchment area (less than 1%). These are individual water bodies with a surface area of less than 1.0 km2. Land reclamation (drainage melioration) as of 01.01.2006 was carried out on an area of 2300 km2, which is about 11% of the total catchment area within Belarus.

Significant reclamation works were carried out within the tributaries of the river basins such as the Pronya (11%), Chechera (14%), Besed (10%), Iput (13%), Uza (27%) rivers. River regime has been studied within 6 posts. Post near Krichev is currently operating.

The Lobzhanka River is the left tributary of the Sozh River on the territory of the Klimovichi (it starts at Nedved village) and Krichev districts. The length is 54 km. The main tributaries are Sobolevka, Perevolochnya, Borovka (left) and Renta (right). The valley is 1–1.2 km wide.

The floodplain is two-sided, with a width of 20–60 m in the upper stream, 200–500 m over the rest area. The river bed in some areas is canalized. The banks of the natural channel are steep. The catchment area is 489 km2. There is a dam on the river near the town of Klimovichi, near Yanovka village.

The Besed River is the second in terms of size and the third in terms of water content tributary of the Sozh river. It originates from a small swamp, in 2,0 km to the south-west from village Belovshchina of the Shumyachsky district of the Smolensk region and it flows into the Sozh river from the left bank. The length of the river is 261 km, the catchment area is 3880 km2.

The main right bank tributaries are the Elenka, Surov, Zhadunka, Derazhnya rivers. The main right bank tributaries are the Alshovka, Jadun, Stolbunka rivers.

The catchment area occupies the southeastern part of the Orsha-Mogilev plateau.

Vegetation is represented by forest and shrub (20%). Swamps of lowland and transitional type occur in small areas in the depressions. There are few lakes (less than 1%). The bed is free meandering, strongly wandering, with a lot of bays, lakes, low sandy flooded islands. There are aquatic vegetation which is thickly overgrown on reefs and shallow areas. The predominant width of the river is 30–40 m, the largest is 120 m near Starye Gromyki village. The banks are steep, often abrupt, eroded, with a height of 0.3 to 2.0 m.

The river regime was studied within 8 posts. The post near Svetilovichi village is currently in operation.

The Iput River is the left tributary of the Sozh River (the Dnieper River basin). It flows through the territory of Mogilev (Klimovichi) and Gomel (Dobrush, Gomel) regions of Belarus, as well as Smolensk and Bryansk regions of Russia.

The head of the river starts in the Mogilev region and flows into the river Sozh near Gomel. The total length of the river is 437 km. On the territory of Belarus it reaches 64 km. The catchment area is 10900 m2. The river valley is trapezoidal. In the head part the width is 1–1.5 km, below – 2.5–3.5 km, within the area from the hydrological post to the entry – 4–8 km. Floodplain is two-sided, sometimes alternating along the banks. The width of the upper streams varies from 1.5 to 12 m, over the rest distance it reaches 20–50 m.

The Pronya River is the right tributary of the Sozh River (the Dnieper River basin). It flows through the territories of the Chausy, Horki and Slavgorod districts of the Mogilev region of Belarus. It originates from the Smolensk Hill, in the Chausy district near Lenenka village and flows into the Sozh near Slavgorod. The length is 172 km. The main tributaries are Golysha, Basya, Resta (right), Porositsa, Bystraya, Verbovka, Koshanka (left). The catchment area is 4910 km2. Within the Orsha-Mogilev plain it is cut by ravines and 22% is covered by forest. The average annual water discharge in the entry is about 30 m3/s.

The valley of the Pronya river is well developed and deeply embedded. The width in the upper reaches is 0.4–0.6 km, in the lower reaches it is up to 1–2 km. The floodplain is two-sided, the width is 250–500 m. In the river mouth the width is 0.8–1.2 km, in some areas reaching up to 80 m. Below the mouth of the Bystraya River it extends to 3.8 km. The bed is meandering. The width is 15-20 m, and in the lower streams it is up to 40–50 m. The banks are predominantly steep, abrupt, and low and swampy in the upper streams.

The feeding is mixed, with a predominance of snow. About 74% of the annual runoff occurs in the upper stream during the spring flood period. In the lower stream it reaches less than 58%. The average elevation above the low-lying level is 2.8–3.8 m.

Within the territory up to the town of Horki, the river freezes at the end of November. Within the territory below, the river freezes in the first decade of December, and it is opened at the end of March - beginning of April. In summer, rain floods can occur.

The Basya River flows in the Dubrovna district of the Vitebsk region, the Horki, Shklov and Chausy districts of the Mogilev region. The Basya River is the right tributary of the Pronya river (Dnieper river basin).

The length is 104 km. The catchment area is 955 km2. The average annual water discharge in the estuary is 6.3 m3/s. The total fall is 70.7 m. The average slope of the water surface is 0.68 ‰.

It originates within the Smolensk Hill on the southern suburbs of Antipenka village in the Dubrovna district, flowing along the Orsha-Mogilev Plain. The watershed is slightly hilly, rugged by ravines and valleys. 20 % of the area is covered by forest. The main tributaries are the Limna, Avcheza, Ryuza (right), Polna, Golubina, Chernitsa, Kasinka (left).

The valley is 300–500 m wide. Slopes are steep, with a height of 4–10 m. The floodplain is 150–300 m, two-sided, cut by the old channels and tributary valleys. During the flood period it is flooded to a depth of 0.3–1.0 m, in the lower streams it can sometimes be flooded up to 1.5–2 m. The bed is moderately meandering, weakly branched. In the upper streams for 18 km the bed is channeled, in some areas it is cleared. The width of the river in low-water season is from 2–4 m in the upper streams, and up to 10–15 m in the lower streams. The banks are steep. 68% of the annual flow occurs during the spring period, 23% is during summer-autumn, and 9% is during winter. It freezes in early December, and is opened in the third decade of March. Hydrological observations are held at the Hilkovichi post.

The Vihra River is the river in the Mogilev Region and in Russia. It is the right tributary of the Sozh River (the Dnieper Basin). The length is 158 km; within Belarus the length is 40 km. The catchment area is 2230 km2, in Belarus is 360 km2. The average annual water discharge in the entry is 14.5 m3/s. The average slope of the water surface is 0.4 ‰. It originates in the Krasninski district of the Smolensk region of Russia, and then flows through the territory of the Mstislavl district. The main tributaries are the Trostyanka, Upokoy, Zheleznyak, Velnyanka (on the left), Rufa, Malakhovka, Gorodnya, Knyaginya, Chernaya (right).

Within Belarus it runs through the Horki-Mstislav Plain. The valley in the upper stream is not clearly defined. It is trapezoidal below the stream, with a width of 1.5–2 km. The floodplain is two-sided, with a width of 0.4–0.6 km. The river bed is meandering; the width of the river is 15–20 m. About 57% of the annual runoff occurs during the spring period. The maximum level of high water in the first decade of April. The average height above the lower level is 4.2 m. It freezes in the first decade of December, and is opened at the end of March. Spring ice drifts about for 4 days.

Hydrological observations are carried out within the Mstislavl post. 9.9 km of the channel in the lower stream is canalized. The banks are steep, often abrupt.

1.3.1.3 Lakes

There are few lakes in the catchment area (<1%). They are mainly located in the southern part of the catchment area. These are small (with a surface area <1 km2) overgrown reservoirs (represented in Table 3 of Appendix A).

The largest lakes in the Dnieper basin.

Lake Plavno. It is located 8 km away in the north-west from the village of Domzheritsy. The surface area is 4.02 km^2. Lake has the residual type. The length of the lake is 3.45 km; the maximum width is 1.75 km. The maximum depth is 2 m; the average depth is 1.3 m. The slopes of the basin are not defined. The lake is located among the swamp. 69.2% of the territory is occupied by forest area. The coastline is 9.05 km. The banks are low, sometimes fused, bogged and shabby. The channel from the Olshitsa lake and one stream flows into the Lake Plavno. The Berezinsky channel and the channel flow into the Lake Manets. The catchment area of 186.5 km^2 has a low relief. It is composed of sands and sandy loams. It is mainly occupied by forest. Forests and shrubs occupy 69.2% of the catchment area. The lake is dystrophic. The width of plant colonization

is 5–25 m. Lake is overgrown by underwater plants by 100%. Lake is a part of the Berezinsky Biosphere Reserve.

Lake Olshitsa (the Dokshitsy region). The area of the water surface of the Lake Olshitsa is just reaches 4 km^2. The underlying basin has the form of a drop. Slightly stretching, it smoothly passes into the channel, through which the return of excess water to the neighboring Lake Plavno occurs. Average depth in Lake Olsitsa is only 1.2 m, and the deepest point is at a distance of 2.7 m from the water surface. A small amount of water quickly exchanges. The flowage of lake also contributes to the water exchanges. It flows into the river Serguch. The inflow is also carried out along several ditches. Neither the river nor the ditches can't be seen, because they are sufficiently densely overgrown, but the inflow of water along them makes up the major part of the feeding of Lake Olshitsa. The outflow of water is due to the flow to Lake Plavno. Lake Olshitsa is almost completely open, which creates all the conditions for wind circulation of water. A small depth contributes to the fact that the water in the lake warms up basically to the very bottom. Thus, the decay processes in the Lake Olshitsa are accelerating. As the water temperature is higher than+ 4^0C even in winter, "lake life is in full swing" all year round. Numerous plants and algae consume most of the oxygen in the water, which leads to a decrease in the number of fish in the pond (due to lack of oxygen in the water, it simply dies in winter). Even right now phytoplankton and microorganisms which are specific to swampy water bodies can be observed. Only the boys coming to the lake to fish from the nearby villages are satisfied with fish species diversity.

Lake Medzozol is located 1.8 km east away from Nesmerechina village. The surface area is 3.02 km^2; the volume of the water mass is 8.1 million m^3. Lake has the residual type. The length of the lake is 2.96 km; the maximum width is 1.4 km. The maximum depth is 5.3 m; the average depth is 2.7 m. The slopes of the basin are slight, low, sandy, loamy and plowed. 34% of the territory is covered by forest massifs. The coastline is 9 km. Shores are low, sandy, sometimes bogged and swamped. The river Berezina inflows and outflows, and it has two streams. The catchment area of 381 km^2 has a low-lying and flat-wavy relief. It is consist of loams and sands. It is weakly plowed. Forests and shrubs occupy 34% of the catchment area. The lake is eutrophic. The width of plant colonization is 15–100 m. The total width of the overgrowth is 25–250 m. Lake is used for industrial fishing. It is a water intake of a drainage network. Lake is filled with silver crucian carp, crucian.

Sergeevichi Lake is the largest lake in the Pukhovichi district. It is located about 70 km away from Minsk. The lake is quite shallow; it has only 2 m in the deepest place. It has a muddy bottom. It is located in the basin of the Ptich river, 25 km away to the west of the town of Marina Gorka, within the northern suburbs of Sergeevichi village. The area is 2.75 km^2, the length is 2.2 km, the maximum width is 1.6 km, and the maximum depth is 2.9 m. The catchment area is 1.2 km2. The basin has a rounded form. The slopes are low, swampy, covered with shrubs. The banks are hilly, covered with forest and shrubbery. There are pike, bream, roach, crucian carp, reddish, tench, and perch in the lake. In the southeast, there is runoff through the channel to the river Ptich. The bottom is covered with putrid mud of carbonate type (area is 248 hectares). The maximum thickness is 11.5 m, the average thickness is 3.4 m, and volume is 8440 thousand m^3. The deposit is reserved for the republican resort "Zhdanovichi".

Lake Mezhuzhol is located in the Vitebsk region, Dokshitsy district, 9.8 km northeast away from Tumilovichi village. The area of the surface is 2.86 km^2; the volume of the water mass is 1.82 million m^3. Lake has the residual type. The length of the lake is 3.88 km; the maximum width is 1.05 km. The maximum depth is 3 m; the average depth is 0.6 m. The slopes of the basin are not defined. The lake is located among the upper marsh. The slopes are occupied by forests by 57%. The coastline is 9.15 km. The shores are low, and high in the north-east. They are peaty and swampy. The catchment area of 53.4 km^2 has a low relief. It is consist of sands and peat bogs. It is mainly covered by forest and bog. Forests and shrubs occupy 57% of the catchment area. The lake is dystrophic. The width of plant colonization reaches 15 m. The total width of plant colonization is from 0 to 75 m.

Lake Orekhovsk (Bolshoe Orekhovskoye) is a lake in the Orsha district of the Vitebsk region. The area is 2.11 km^2; the greatest depth is 3.5 m. The length is 3.93 km, the largest width is 1.08 km, the length of the coastline is 10.8 km, the water volume is 4.34 million m^3, and the catchment area is 33.4 km^2. The lake is

in the Orshitsa river basin (flows out from the lake), 20 km north away from Orsha, near Orekhovsk. The basin is extended. The slopes are covered by forest. They are 2–5 m high and up to 10–15 m high to the north-west. The banks are low, bushed, and high, steep to the east and north-east. There is an island of 2.4 hectares. The littoral is sandy; the bottom is covered mud and putrid mud. It is poorly covered by plants. There are 2 inflowing streams and the Chernaya river.

Lake Sudoble (Sudoblya, Sudobl') is a lake in the Smolevichi district of the Minsk region. It is located in the Plissa river basin, 20 km east away from Smolevichi, 4 km south-east away from Zhodino. The area is 1.52 km^2, the length is 1.5 km, and the maximum width is 1.8 km. The catchment area is 22 km^2. The banks are full of floating bogs. The width of the floating bogs is 50 –75 m, the height is up to 0.5 m. In winter the lake freezes down to the bottom. It is completely overgrown by plants. It is full of crucian carps. The bottom is covered by putrid mud. This deposit of putrid mud is the deepest on the territory of Belarus. It is the first formation of medical putrid mud in the republic, and it has been developed since the 1980s. The thickness of putrid mud is more than 25 m in the center of the lake. The volume of organic putrid mud is 7266 thousand m^3; the average power is 5.8 m. Putrid mud is widely used in sanatorium-and-health organizations of Belarus, including the resort "Zhdanovichi".

Lake Manets. The area of the lake is 1.44 km^2. The lake is shallow, the maximum depth does not exceed 1.3 m, and the average depth is 0.67 m. The basin is oval, stretched from the north-east to the south-west by 2.7 km and represents a lake-like extension of the river. The lake is well running. The characteristic of the water balance and hydrochemical regime is the same like in the Olshitsa and Plavno reservoirs. Some differences are associated with the thickness and material composition of bottom deposits of Lake Manets. A layer of coarse-grained putrid mud is up to 1.5 m thick with organic matter content of more than 35% is underlaid by a 3-3.5-meter layer of carbonate putrid mud, which is replaced below by deposits of mixed composition. Clayey mud and clay lie deeper. Macrophytes completely cover the whole bottom. And both surface and submerged macrophytes are equally spread. By the phytoplankton development, Manets is one of the poorest of all lakes in the Berezina reserve, which indicates that it belongs to dystrophic reservoirs. In total, 20 species of algae with a total biomass of 0.3 g/m^3 are found in the lake. The predominant group is diatoms. 27 species are identified in the zooplankton sphere. Their biomass is 0.83 g/m^3. The benthos fauna reaches a noticeable development (23 species), but its distribution is extremely uneven. In the thickets the amount of the benthos fauna reaches 15 g/m^2. In the whole reservoir the amount is no more than 4.3 g/m^2. The larvae of chironomids, oligochaetes and mollusks have the greatest weight.

1.3.1.4 Reservoirs

The amount of reservoirs in the Dnieper River basin (without the Pripyat river basin) according to the gradations of their full volumes is given in Table 1.4.

Table 1.4 – Classification of reservoirs in the Dnieper River Basin by volume

Water volume, million m^3								Total	
1.00 – 10.00		10.01 – 50.00		50.01 – 100.00		Более 100.00			
Number	Total volume	Number	Total volume	Number	Total volume	Number	Total volume	Number	Total volume
37	91.30	7	144.10	2	114.60	1	103.00	47	453.00

The most significant artificial reservoirs are Gonoles (Zaslavl), Osipovichi (Svisloch River) and Chigirinsk (Drut River). The basic information on the reservoirs of the Dnieper River Basin is given in Table 3 of Appendix A.

Melioration systems

Reclamation works were carried out within the catchment basin of the Dnieper River, and in the result about 14% of the basin area was reclaimed, about 38500 km of open drainage network of canals were put in commission.

More reclamation works (drainage) was carried out in the basins of the Dnieper tributaries, such as the Drut (11%), the Dobysna (28%), the Berezina (15%), the Vedrich (25%), and the Sozh (11%) rivers (Table 1.5).

Table 1.5 – Area and length of the melioration network within the Dnieper River basin

№	Name of the water body	Post location	Area of the ameliorative territory,km^2	Length of the melioration network, km	
				open	closed
1	The Dnieper	Orsha	313	691	14459
2	The Dnieper	Mogilev	575	1593	26105
3	The Dnieper	Zhlobin	1655	8456	57078
4	The Dnieper	Rechitsa	5992	25829	153114
5	The Uhlyast	Radkov village	51.9	766	-
6	The Drut	Gorodische village	388	1830	14325
7	The Drut	Chigirinskaya HPP	437	2551	15936
8	The Dobysna	Malevichskaya Rudnia village	96.3	468	3112
9	The Berezina	Borisov	600	3216	8894
10	The Berezina	Bobruisk	2843	10627	56794
11	The Bobr	Kuty village	31.1	99	813
12	The Usa	Bogyshevichi village	14.4	37	625
13	The Svisloch	Hmelevka village	2.13	10	-
14	The Svisloch	Zaslavsky hydraulic power station	41.2	163	1011
15	The Svisloch	Korolischevichi village	56.9	239	1330
16	The Svisloch	Terebuty village	906	2185	14756
17	The Grava	Aminovichi village	8.49	36	230
18	The Neseta	Krasny Bereg village	90.5	462	3296
19	Ivnya-Bonda channel	Budka village	121	566	2462
20	The Sozh	Krichev	91.1	512	4022
21	The Sozh	Slavgorod	812	3826	33171
22	The Sozh	Gomel	1874	8676	64840
23	The Vihra	Mstislavl	24.3	227	1138
24	The Oster	Hodyn village	3.46	22	72

№	Name of the water body	Post location	Area of the ameliorative territory,km^2	Length of the melioration network, km	
				open	closed
25	The Pronya	Letyagi village	516	2452	21309
26	The Basya	Hilkovichi village	89.6	340	5163
27	The Besed	Svetiloovichii village	337	1314	12982
28	The Zhadunka	Kostukovichi	25.0	102	892
29	The Iput	Dobrush	193	725	4805
30	The Uza	Pribor village	209	629	6582

The Berezina water system is an artificial waterway connecting the Dnieper basin with the Western Dvina River. The length is 162.1 km. There were 14 floodgates and gateways and 4 drainage outlets. It was mainly operated in the XIX century.

The Berezina water system ran along the Berezina river from Brody, the Serguch channel (3 floodgates, 8.7 km), the Serguch and Buzyanka rivers, the Manets and Plavno lakes (connected by a 4 km long channel), the Berezina channel (4 floodgates, 7.6 km), Berescha lake, the Berescha river, the Verebsky channel (2 floodgates, 2.6 km), the Esa river, the Pervyi Lepel channel (2 floodgates, 8 km), the Lepel lake, the Vtoroi Lepel channel (1 floodagte, 0.2 km), the Ulla river, Chashniki channel (2 floodgates, 1.2 km), again the Ulla river, the Western Dvina river.

The first projects of connecting the Dnieper with the Western Dvina were developed in 1701. The idea of the Berezinsky channel belongs to the Polish nobleman Chatsky (1794). The Berezinsky water system was built in 1797–1805 (I.K. and F.I. Gerardy, M.I. Freigang, Ya.E. De Witte, F.P. Devolan). It was reconstructed in 1810–1812, 1823–1836, 1870–1880-ies.

The system contributed the export of agricultural products and raw materials, as well as forests from the Mogilev and Minsk provinces to the Riga port. Until 1817 and from the 1880s, navigation was carried out. At the end of the 19th century up to 40–50 million poods of cargo passed. The conflict of railways led to the collapse of the system at the beginning of the 20th century. Nevertheless, even until 1941 the forest was floated through this system, but during the war the floodgates were exploded and the channels finally declined. At present, part of the channels is used by tourists-enthusiasts for travelling by waterways.

At present, the once-busy water route has completely lost its timber and transport value. The timber rafting through this system deceased in the 50s. The timber rafting along the Berezina river ended up in 1975. The wooden hydraulic structures collapsed. The only reminders are the stone slopes of floodgate chambers and dams, half-rotten remains of wooden structures, which can still be seen at the bottom of the channels. Today it is the occupation for beavers, otters, ducks and thousands of other flora and fauna representatives of the reserve.

4.3.2 Surface water resources

Climate features defines the hydrological regime of the Dnieper and its tributaries. River basins have mixed sources. The main source is snow water, which forms a significant part of the runoff (50%), as well as underground water (27%) and rainwater (23%). The role of snow water gradually increases downstream of the Dnieper River.

Spring flood of the Dnieper River is characterized by one wave, less often by two waves. 68% of the annual runoff is in the spring flood period, 28% is for the summer, and 4% for the winter runoff. To the south

direction, the percentage of spring runoff is reduced to 57%, summer-autumn and winter runoff is increased to 30% and 13%, respectively. A stable freeze-up is formed in the end of November or early December. In particular years the maximum thickness of ice reaches 60–80 cm. The river is opened at the end of March and beginning of April, the spring ice drift lasts from 4 to 7 days. The average water temperature in the summer reaches 19–22°C.

Primary hydrological characteristics

The Dnieper River is fed by several sources. The main source is snow water forming a significant part of the flow (50%), as well as groundwater (27%) and rainwater (23%). The role of snow waters gradually increases downstream of the Dnieper river, while the role of rainwater is sharply reduced.

In the upper stream of the Dnieper River, the total flow rate varies slightly from year to year, increasing and exceeding the norm 1.5–2 times in high water years, or decreasing to 0.5–0.7 out of the norm in shallow years. The flow of the Dnieper River in the period of high water makes up about half of the total annual flow. During the spring flood period, 60-70% (sometimes up to 80%) of the total annual runoff passes, followed by a low summer season. Floods occur in the autumn (with rainfall) and in winter (during the thaw period). Thus, the summer and autumn runoff of the river is 25-35% of the total annual flow, and the winter runoff is 10-20%.

The average annual water discharge of the Dnieper River in the mouth is 1670 m^3/s, near Orsha is 123 m^3/s, in Mogilev is 139 m^3/s, and near Rechitsa is 364 m^3/s. In Orsha, the maximum flow rate is 2000 m^3/s (in 1931), the minimum flow is 8 m^3/s (in 1892), the maximum flow rate for Rechitsa is 4970 m^3/s (in 1958), and the minimum is 36 m /3s (in 1921).

Local runoff is unequally distributed across the basin, where the uppermost part of the basin is the most flooded water source. The drainage modulus in the basin varies from 6.5 $l/s/km^2$ in the area of Orsha to 3.5 $l/s/km^2$ below Gomel.

The Dnieper freezes in late November – early December, and is opened in late March – early April. The maximum thickness of ice is 60–80 cm (in early March). Spring ice drift lasts for 4–9 days. The average water temperature in the summer is 19–22 ° C. The highest temperature in July is 28 °C (in 1954).

From late November to late March, the river freezes and the maximum ice thickness reaches 60-80 cm. In recent years, this period has significantly decreased.

The spring flood period usually passes by one wave, begins in the second half of March and lasts for 2–2.5 months. During flood period, the water level rises to 4.5–6 m or more. The highest water level during the flood period was fixed in Orsha on 23 April 1931, and reached 9 m 49 cm. The difference between the largest and the smallest water levels on the Dnieper over the entire observation period ranges from 4.95 m in Zhlobin to 9.41 m in Orsha. In Mogilev and in Loev it reaches almost 8 m. As for the Dnieper, the most water-abundant are 1931 and 1956 years.

The total forecasted groundwater resources in the basin are about 24 km^3, including more than 13 km^3 of groundwater, which do not have a hydraulic connection with surface runoff.

The main hydrological characteristics of the Dnieper River and its main tributaries are given in Table 1, 1.1-1.4 of Appendix A.

Hydrochemical characteristics of fluvial water

The biogeochemical factor in the formation of the chemical composition of fluvial waters, which reduces their mineralization and enriches waters with organic substances, is most clearly characterized for the right tributaries of the Dnieper (the Berezina River, the Drut River, the Vedrich River), the catchments of which are largely swamped and covered with forests. Large areas of peat-bog massifs, mostly afforested, occupy 24–44% of the catchment area. Dry forests are also widespread. They occupy 30–49% of the catchment area.

The increase in the mineralization of the waters of the right-bank rivers is associated, as a rule, with a lithological and geochemical factor. The effect of lithological and geochemical factor increases when the water-bearing complexes of the Devonian, Upper Cretaceous and Upper Jurassic deposits enter the drainage zone of the rivers. Thus, the Berezina river system in the upper and middle streams (the Bobr, Plissa, Gaina, Usha rivers) partially drains an aquiferous complex of the Middle Devonian. The drainage zone of the rivers Svisloch, Berezina (middle course) and Olsa include shallow Upper Cretaceous deposits. The lower stream of the Berezina river and the Vedrich river cut down the Neogene-Paleogene rocks and the underground waters of Upper Cretaceous and Upper Jurassic carbonized sediments are partially opened. In this regard, the Vedrich river, whose catchment area is swamped and covered by forests by an average of 47%, has a high calcium content (58.8 mg/dm^3), magnesium (10.9 mg/dm^3) and hydrocarbonates (209.8 mg/dm^3) with mineralization reaching 317.2 mg/dm^3.

The conditions for formation of the composition of the waters of the Dnieper left tributaries are significantly different from the right ones, which can be clearly seen in the features of their hydrochemical regime. The impact of the biogeochemical factor is significantly weakened, and the lithologic-geochemical factor is increasing. Thus, the marshiness and forest coverage of the catchment areas of the Sozh river and its tributaries are very insignificant (1–10 and 7–24%, respectively). The covering rocks here are mainly loess-like loams and sands, underlain by chalk and marl deposits, which are exposed along the banks of the Sozh river and some its tributaries. In the catchments of the Pronya river and especially Vichra river, Cretaceous deposits occur among the covering rocks. The role of the lithogenic factor is clearly seen in the summer and winter low-water period, increasing the mineralization of water in some cases to the maximum values for the rivers of the country.

The hydrochemical regime of the upper Dnieper and rivers in the basin of the Sozh river is characterized by a large amplitude between the amount of mineralization in the period of spring flood and winter low-water period. In spring the mineralization of water is 7–9 times lower than in the low water period. In the Berezina River basin this ratio is no more than 3–4 times, and it is the smallest for the rivers of Belarus.

During the high flood period, the salinity of river waters in the Dnieper Basin varies from 46.7 to 139.4 mg/dm^3, in average water year – from 60.5 to 102.1 mg/dm^3, in low water – from 62.3 to 251,5 mg/dm^3. The Vihra, Jadunka, Porosica rivers are characterized by very low mineralization in comparison with rivers which draining wetlands. Their catchments have poorly water-permeable silty-loamy soils which give 90% of thawing water into surface runoff.

The relative content of hydrocarbonates varies from implicitly and weakly expressed (15.9 –27.2%) to a well-expressed (28.7–44.7%). In addition to the above, its absolute concentrations in water vary within a wide range (17.1–134.2 mg/dm^3). An important role in the composition of anions is played by sulfates. Its content in the water of some rivers increases to 12–26%, and sometimes becomes predominant and contributes to the weakening of the expression of the hydrocarbonate characteristics of the waters. An increased content of sulfates is typical for alluvial waters with significantly forested catchment areas (the Berezina, Sushanka, Vedrich). This is associated with the process of mineralization of organic substances in soils and the washing out of the sulfuric acid salts with their subsequent removal to the river network. The absolute amount of sulfates is 5.1–15.5 mg/dm^3, increasing in some cases to 22.3 mg/dm^3 (the Sushanka River) and 38.5 mg/dm^3 (the Vedrich River). The content chlorides is small (0.0–7.8%), which corresponds to 0.0–5.8 mg/dm^3.

Calcium dominates (30.5–40.5%) in the spring waters and its concentration in the alluvial water varies from 9.6 to 30.9 mg/dm^3, not exceeding 20 mg/dm^3. The magnesium content reaches 1.0–8.6 mg/dm^3 or 6.9–

14.9%. The total concentration of sodium and potassium does not exceed 0.2–4.8 mg/dm^3, and the relative concentration – 0.8–8.6%.

During low water period, the mineralization of alluvial waters largely increases, mainly due to drainage by rivers of waters of the Upper Cretaceous deposits, which are associated with the inflow of waters with significant concentrations of HCO3-, Ca2 +, Mg2 +.

In the summer low water period, mineralization of alluvial water is 249.3–496.6 mg/dm^3, in winter low water period is 264–573 mg/dm^3. The waters of medium mineralization (200–400 mg/dm^3) are distributed within the main part of the basin. Its higher values (more than 400 mg/dm^3) are characterized for the Dnieper River (Orsha, Mogilev), the Vihra River (Kurovichi village), the Porositsa River (Horki), where loess deposits are widely represented.

The peculiarity of the chemical composition of the Dnieper and the Sozh water is that there is reduction of their mineralization from the upper streams to the mouth. The reduction is connected with the outlet of rivers from loess areas and the flow of water from swampy and forested areas into them. The rivers of the northern part of the Dnieper basin (Adrov, Orshitsa), which are draining loess and loess-like deposits, are enriched with carbonates. Their composition is characterized by a high content of HCO3-, reaching 286.7 mg/dm^3 (the Adrov River) and 263.2 mg/dm^3 (the Orshitsa River), Ca2 + – 63.3 and 55.0 mg/dm^3 and Mg2 + – 15,2 and 21.3 mg/dm^3 respectively. Going forward, the Dnieper has tributaries with the content of HCO$_3$ decreasing to 170.8 mg/dm^3, Ca2 + to 42.5 mg/dm^3, and Mg2 + to 10.6 mg/dm^3.

The mineralization of the upper tributaries of the Sozh River (the Vihra River, the Chernaya Natopa River, the Pronya River) reaches 338.1–477.0 mg/dm^3. The mineralization of the southern tributaries (the Udoga River, the Pronya River in the lower streams of the Besed River) is 215.2 –312.0 mg/dm^3.

In low water periods, all the rivers of the Dnieper Basin have an expressed hydrocarbonate character (38–48%). In this case, the concentration of hydrocarbonates reaches 158–373 mg/dm^3 in summer and 150–398 mg/dm^3 in winter, exceeding in 3–14 times their content during the spring flood. The hydrocarbons content rises especially in the Sushanka river (8–12 times) and the Vihra river (8–14 times), significantly reducing the content of sulfates in the anionic composition (0.9–6.6%). Moreover, the absolute concentrations of the sulfates vary widely between 3.3–24.6 mg/dm^3 in summer low water period, 5.6–24.0 mg/dm^3 in winter low water period. The chloride content in the alluvial water varies mainly around 0.4–8.0 mg/dm^3, occasionally rising to 12.9–15.5 mg/dm^3 (near large settlements), which is 0.7–5.1%.

Calcium predominates in the composition of cations (28–40%), while its absolute quantity varies from 40.9 to 80.8 mg/dm^3 in summer and from 37.9 to 89.6 mg/dm^3 in winter. The magnesium content is 6.4–24.6 mg/dm^3 in summer and 6.4–29.4 mg/dm^3 in winter, which equals 5.3–16.8%.

The total content of potassium and sodium does not exceed 9%, and the absolute content varies from 0.2 to 16.8 mg/dm^3 in summer low and from 2.5 to 16.0 mg/dm^3 in winter.

4.3.3 Groundwater

In the Dnieper river basin in Belarus, seven groundwater bodies (GWBs) were distinguished and delimited: three in the Quaternary aquifers, and four in the artesian aquifers of the Quaternary sediments (Table 4.8 of Appendix A, map-scheme No.18 of Appendix B).

The territory of the Dnieper Basin covers a number of large geological structures of the first order, which are isolated hydro-geological regions. They are distinguished by the thickness and age of the sedimentary deposits, their lithological composition and occurrence conditions. Together with the difference in climatic and orogidographic conditions of various parts of the basin, these factors define the patterns of distribution and groundwater formation, their movement nature, pressure, resources, quality and conditions of their operation.

The feeding of shallow aquifers is carried out everywhere due to atmospheric precipitation and condensation of moisture in the aeration zone. In the direction from north to south, the supply conditions decay. It is firstly connected with the double reduction in the amount of annual precipitation. It is secondly connected with the change of permeable sandy alluvial deposits in the Quaternary cover, developed in the northern regions, to clay formations whose thickness naturally increases to the south.

The direction of the underground flow in the hydrodynamic zone is determined by the flow of the Dnieper and its tributaries. Draining effect of the hydrographic network impacts on both groundwater and deep-lying aquifers. The valleys of the largest rivers of the basin (Dnieper, Berezina, Sozh) are areas of groundwater discharge.

Rational use of groundwater can be based only on a reliable estimated assessment of their resources, the results of which are given in Table 1.6.

Table 1.6 – Resources of fresh groundwater in the basin (according to the data of 2017)

Area	Average modulus, l/s km^2		Natural resources, million m^3/year	Projected operational resources				
	Natural explored resources	Operational resources		Total, million m^3/year	hydraulically associated with surface runoff		hydraulically not associated with surface runoff	
					million m^3/year	% of total	million m^3/year	% of total
the entire Dnieper basin	1.15	1.57	18521	25246	11786	46.7	13.462	53.3

The hydrogeological conditions of the Dnieper Basin within Belarus are determined by its geological and tectonic structure. Two artesian basins have been identified according to hydrogeological features. They are Moscow (Orsha within Belarus) and Dnieper (Pripyat) basins. The boundaries and boundary parts of artesian basins are confined to the arched parts and slopes with the positive tectonic structures of the crystalline basement such as the Belorussian and Voronezh anteclises, the Zhlobin and Bragin-Love saddles, and the Bobruisk brow.

The Orsha artesian basin is the western part of the Moscow megabasin. It occupies the northern and northeastern part of the Dnieper Basin within Belarus. The thickness of sedimentary rocks reaches 1500–1700 m. The zone of active water exchange reaches a thickness of 300–350 m, decreasing to 200 m towards Zhlobin saddle. In the zone of active water exchange, the aquifers of the Quaternary, Cretaceous, Upper Middle Devonian and Upper Proterozoic deposits (within the Belorussian anteclise) are widespread. The maximum thickness of sedimentary rocks within the basin is 6200 m. The zone of active water exchange extends to a depth of 200–300 m. It includes the aquifers of the Quaternary, Neogene, Paleogene, Cretaceous, Devonian, and Upper Proterozoic deposits within the Belorussian anteclise.

The characteristics of the main aquifers

The basin of the Dnieper River within the Republic of Belarus is composed of a thick cover of Quaternary and pre-Quaternary sediments (50–6000 m), represented by water-tight and weakly water-tight rocks, to which a large number of aquifers and complexes are confined. The main aquifers and complexes in the Dnieper river basin within Belarus, which are used for centralized water supply, are Quaternary, Paleogene-Neogene, Cretaceous, Devonian and Upper Proterozoic (Appendix B, figure 4).

The aquifer of Quaternary deposits

Quaternary sediments, (with a total thickness of up to 100 m and more) covering the basin with a continuous mantle, contain a considerable amount of groundwater, which are widely used for domestic and drinking water supply.

In accordance with the hydrodynamic features of water, quaternary deposits are divided into subsoil and pressured waters.

Subsoil waters are confined to the Holocene alluvial, lake and swamp formations, to the Pleistocene alluvial and lacustrine-alluvial sands, as well as to the super-moraine formations of Poozerie, Sozh and Dnieper age. Water-bearing rocks are usually represented by sands with more or less content of different grains, sand and gravel with interlayers and lenses of sandy loam, loam and clay, with the thickness of several to 10–15 meters, and sometimes even more. Groundwaters are non-pressured. Levels are set close to the ground surface, in lowered areas they crop out to the surface. The water content of the complex is usually low. Specific flow rates of wells vary from thousandths to 2–2.5 l/s. Within areas that are not contaminated, waters of the horizon are fresh, with a mineralization of 0.2–0.7 g/dm^3, hydrocarbonate-calcium and magnesium-calcium. From the point of view of its natural protection, the ground horizon is mainly in unfavorable conditions and is often subjected to heavy pollution. In the areas of agricultural and municipal water pollution, water acquire a complex composition due to the high content of such components as NO_3^-, Cl^-, SO_4^{2-}, K^+, Na^+, etc. Their mineralization increases to 1.0–1.5 g/dm^3 or more. At the same time, water of the horizon is widely used by the population for water supply, especially in rural areas, where they are operated with the help of mine wells.

In the Quaternary strata, *Pressured waters* are confined to complexes of fluvio-glacial deposits lying between moraine sandy loams, loams and clays of Poozerie, Sozh, Dnieper and Berezina glaciations. Within Belarus in the northern and central parts of the Dnieper river basin there are 3 intermorainal pressure complexes. One complex is in the south and east of the Dnieper river, and 2 complexes can be met less often. Water-bearing Dnieper-Sozh and Berezin-Dnieper water-ice complexes are most widely used.

The water-bearing Sozh-Poozerie water-ice complex in the Dnieper Basin is not practically used for centralized water supply.

The water-bearing Dnieper-Sozh water-ice complex is distributed almost everywhere in the northern part of the Dnieper Basin, absent in river valleys, ancient valleys and valleys of the glacial water flow, and also in small areas where the Sozh moraine lies on the Dnieper. The depth of the aquifer is from 2–40 m in river valleys to 100–195 m within the watersheds.

Water-bearing rocks are sands varying from fine-grained to gravely, with thickness from 0.4 to 107.4 m, sometimes silty and clayey. The fluvio-glacial deposits are covered with moraine sandy loams and loams of Sozh glaciation. Effective capacity of the complex is observed within 0.5–80 m, more often it is equal to 10–20 m. Waters of the complex are pressured, the pressure sizes are predominantly 25–75 m, decreasing to river valleys up to 5 m. Piezometric levels are set at a depth of 1 to 70 m, sometimes up to 9 m above the ground. Specific well flow rates vary from 0.01 to 7 l/s. The coefficient of filtration of water-bearing rocks varies from 0.2 to 50 m/day, averaging 5–15 m/day. Water are fresh (total mineralization does not exceed 0.5 g/dm^3), hydrocarbonate-calcium, soft, moderately hard. In some areas, where the sand layer contains buried peat bogs, there is an increased content of iron in the water (in some areas it is up to 10-20 mg/dm^3). According to the occurrence conditions, the described waters are classified as nominally protected.

The water-bearing complex is one of the main in Belarus. And it is widely used for water supply of large and small water users (Minsk, etc.).

The water-bearing Berezina-Dnieper water-ice complex is widespread. The depth of occurrence varies from several to 170 m and more in ancient buried valleys. Water-bearing rocks are represented by sands from fine to coarse-grained, often with gravel and pebbles, sometimes silty and clayey. The total thickness of the water-bearing rocks varies from 0.3 to 100 m and more. The filtration coefficient varies from 0.2 to 26 m/day. The water of the complex are pressured, the magnitude of the pressure reaches 170 m and more, decreasing in the valleys of large rivers. It acquires a non-pressure character within areas where the Dnieper moraine is absent (the Polesye area). Piezometric levels are set at depths of 1 to 78 m, in river valleys they are sometimes 2.5 m above the surface of the earth.

Specific flow rates of wells vary from hundredths to 4.3 l/s. According to the chemical composition of the water, the complexes refer to hydrocarbonate-calcium-magnesium with a mineralization of 0.2–0.6 g/dm^3.

The deficiency of water is that in a number of cases it has an increased content of iron (1–20 mg/dm^3). Bacteriologically, water is healthy. The water supply of Borisov, Zhodino, and other cities is based on the waters of the complex.

The water-bearing Paleogene-Neogene terrigenous complex is widely spread in the southern areas of the Dnieper river basin within Belarus. The depth of the complex varies from 1.6–10.0 m and 15–50 m to 70–200 m.

Water-bearing rocks are sands with different grain size, with interlayers of clays, silts and marlstones (up to 5–7 m thick), as well as lenses and low-power interlayers of brown coal, which have a significant effect on the chemical composition and general mineralization of the water contained in them. The thickness of the water-bearing strata is mainly 8-10 m. The water of the complex is pressured.

Piezometric levels are set at depths of several to 30 m at a head height of 20–80 m, sometimes reaching 100 m. In some cases (in river valleys and low relief areas) a well-spouting to a height of 0.6–2.5 m is observed.

Bacteriologically, the waters are healthy. According to the criteria of safety, they are classified as nominally protected. Waters are widely used in the south of the republic by both large and small water users (Mozyr, Kalinkovichi, Rechitsa cities, etc.).

Within Belarus in the Dnieper river basin to the south of the Minsk-Mogilev line, deposits of the Cretaceous system contain waters associated with *the Upper Cretaceous terrigenous-carbonate complex and the Cenomanian carbonate-terrigenous horizon.*

The Upper Cretaceous terrigenous-carbonate complex is confined to the Middle Cenomanian and Maastrichian sediments. The water-bearing rocks are represented by chalks which are fractured by varying degrees and karstic chalks, marlstones and chalky limestones containing interlayers of clays and siltstones, and sandy Albian deposits of the Lower Cretaceous and Cenomanian deposits of the lower sublayer of the Upper Cretaceous in the east. The total thickness of the Marly-Cretaceous strata ranges from several meters to 261 m. The thickness of the most fractured and a watered stratum usually does not exceed 30-50 m, rarely more. The horizon is located on the Albian and Lower Nenomanian sediments, at a depth of several to 120 meters or more. It is interlaid by Quaternary, Neogene and Paleogene sediments. Waters of the aquifer are pressured. Piezometric levels are set at depths from 1 to 50 m at a head height from several to 120 and more meters.

Bacteriologically, waters are healthy and widely exploited by both small and large water users.

The water-bearing Cenomanian carbonate-terrigenous horizon is represented by sands from small to fine-grained. It is often represented by clays, with interlayers (up to 1.5–3 m) of weakly cemented sandstones and clays. The depths vary from 5–100 m in the east on the slopes of the Orsha artesian basin to 315–375 m in the Pripyat basin. The thickness of the water-bearing sands varies from 5–6 m near the northern boundary of the distribution to 25–40 m in the southeast, in the vast majority does not exceed 10–15 m. Water are pressured. Piezometric levels are usually set 5–10 m lower, sometimes up to 4.7 m above the ground with a pressure head of 25–260 m. The average pressure is 100–120 m.

Bacteriologically, watera are healthy and widely used for water supply in the cities of Gomel, Zhlobin, and others.

The water-bearing complex confined to the Devonian deposit is widely distributed in the Orsha artesian basin.

At the same time in the Dnieper river basin within the Devonian deposits, three water-bearing complexes with different distribution areas are identified. They are the Upper Devonian terrigenous-carbonate, Staroskolsky and Lanksky terrigenous, Vitebsk-Narovsky terrigenous-carbonate complexes.

The aquiferous Upper Devonian terrigenous-carbonate complex is distributed in the northeast of the Dnieper basin, Slutsk and Soligorsk.

Water-bearing rocks are irregularly fractured, often karstic limestones and dolomites with undrawn interlayers of marls and clays. The depth of occurrence of water-bearing rocks varies from 5 to 180 m. The total thickness of carbonate deposits varies from 14 to 270 m, while the thickness of the most fractured and water-bearing layer does not exceed 50 m. The waters of the complex are pressured; the pressure head reaches 50–130 m. Piezometric levels are set at depths from 2 to 15, less often – 30 m, in river valleys 5–10 m above the surface of the earth at a pressure height of 10–176 m. It is widely used for both centralized water supply of Orsha, Soligorsk, Slutsk, and for water supply to small water users.

The aquiferous Starooskolsky and Lanksky terrigenous complex is widely distributed in the Dnieper river basin. Water-bearing rocks are mainly represented by fine-grained sands and slightly cemented sandstones interlaying with clayey-siltstone rocks. The thickness varies from 3 to 200m, increasing to the centre of the Pripyat and Orsha artesian basins. The depth of occurrence of water-bearing sediments varies from 15–165 m in the northeast in the artesian basin to 1200–1300m and more in the Pripyat hydrogeological basin. The aquifer is pressured. The pressure head varies from 30 to 170 meters or more. Piezometric levels are set at depths of 7–15 m, and in river valleys the depth is up to 6.5 m above the surface of the earth.

Fresh groundwater of this horizon is used for water supply in Mogilev, Bykhov, Bobruisk (together with the waters of the Cretaceous complex).

The water-bearing Vitebsk-Narovsky terrigenous complex is widely distributed in the west of the Dnieper river basin. Water-bearing rocks are represented by fractured, sometimes vugular dolomites, dolomitized limestones, less often marls interlaying with clays, sands and sandstones. The depth of occurrence of water-bearing rocks is 70–300 m and more. The total thickness of the described formation varies from 7 to 200 meters or more. There is a tendency for increasing of the thickness from west to east. Waters are pressured. Piezometric levels are set at depths from 0.2 to 60 m, in the river valleys there are cases of self-ejection from wells.

The fresh water of the complex is used for water supply in the cities of Minsk, Osipovichi, Smolevichi and others.

The aquiferous Upper Proterozoic terrigenous complex is widely developed in the Dnieper river basin within Belarus. There is no such complex in the eastern part of the Pripyat Artesian Basin. The water-bearing rocks are represented by sands of various grains and sandstones with interlayers of clays, siltstones and tuffaceous rocks. The thickness of the complex varies from the first meters to 500 m. The water-bearing complex is pressurized. Piezometric levels are set at a depth of up to 188 m, sometimes up to 10 m above the surface of the earth, at a pressure head of 50–224 m.

The fresh waters of the complex are used for water supply for Minsk, Kletsk and others. The map-scheme No.5 of Appendix A shows the results of the assessment of groundwater protection in the Dnieper basin.

5 DETERMINATION OF ENVIRONMENTAL ISSUES OF THE RIVER BASIN AND THEIR SOLUTION

The determination of environmental issues is based on a general analysis of water use in the Dnieper basin and the dynamics of its change, assessment of point and diffuses sources of pollution.

5.1 General analysis of water use and environmental issues

Industries located in the Dnieper river basin are in favorable conditions for the provision of water resources which contribute to the further development of the economy.

Enterprises use surface water and groundwater as a source of water supply.

The total volume of water extracted from surface water bodies and collected from underground water bodies by all water users in the Dnieper river basin in 2017 was 552.812 million m ^{3}. The extraction from surface water bodies is 175.561 million m^3 (32%), the extraction from groundwater bodies is 377.251 million m^3 (68%).

The structure of water use in the Dnieper river basin is not essentially different from the general structure of water use in the country. A peculiarity of the basin is the flow of additional water volumes due to the transfer of the flow of the Vileyka-Minsk water system from the basin of the Vilya river for water supply of Minsk.

Surface waters are mostly used for agriculture, fisheries (fish farms), industry, energy (Figure 3.1).

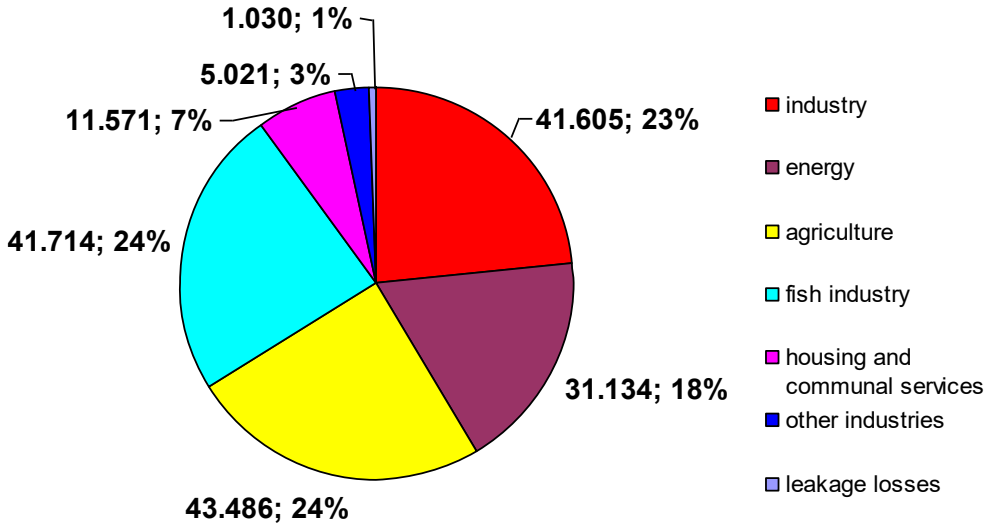

Figure 3.1 – The use of water from surface water bodies by types of activity for 2017 (million m^3/ year/%)

Groundwater are mostly used for housing and communal services (drinking water supply), agriculture and industry (main for ensuring drinking water supply in these activities) (Figure 3.2).

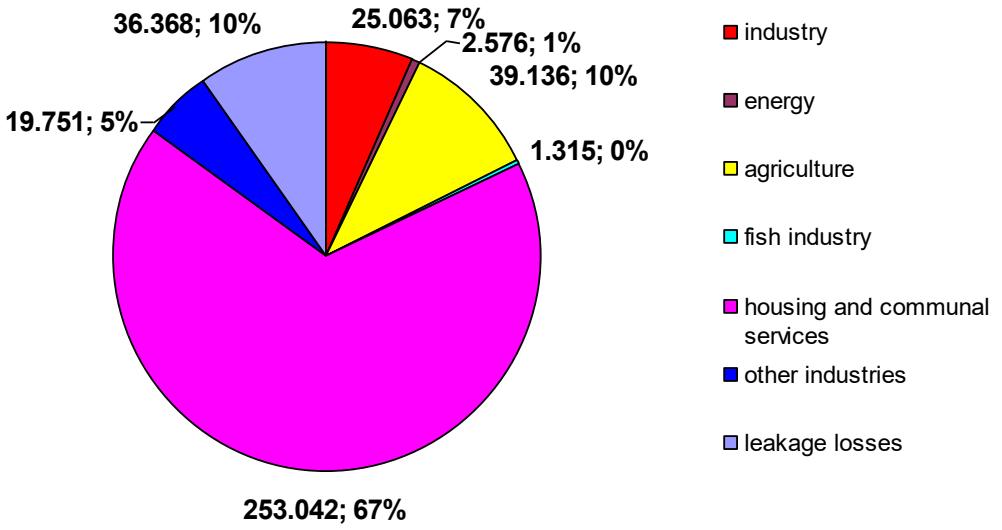

Figure 3.2 – The use of water from underground water bodies by types of activity for 2017 (million m^3/ year/%)

Table 5 of Appendix A reflects the characteristics of water use by the river basin by district, and region centers. Per-capita water consumption for the river basin is given in table 5.1 and ranges from 44.8 to 218.7 l/day/person.

Maps of withdrawal, water use and specific water consumption are given in Appendix B (figures 23,24,25).

Totally, in accordance with the statistical reporting of water use within the State Water Cadastre in the Dnieper Basin, there are 1161 water users within the territory of Belarus in 2017.

The Dnieper basin in the territory of Belarus is industrially and agriculturally developed, and therefore, the impact of surface and groundwater resources on social development and the main sectors of the economy are significant.

Since 2005, the amount of water intakes and the volumes of produced groundwater have been constantly decreasing. The average daily volume of water abstraction in comparison with previous years has decreased practically over all exploited horizons. For this period a significant decrease and extraction of surface waters has occurred (Figure 3.3).

The largest users of fresh water (with a volume of more than 5000 thousand m^3/year) in the Dnieper river basin are the municipal unitary production enterprise Minskvodokanal, the communal production unitary enterprise Gomelvodokanal, the Mogilev city communal unitary enterprise Gorvodokanal, the electric power industry group Gomelenergo that is the branch of Svetlogorskaya TTP, OJSC Svetlogorsk Pulp-and-Cardboard Combine, fish farm "Volma", Bobruisk Communal Unitary Subsidiary Enterprise" Vodokanal ", OJSC "The fish-farm “Svisloch”.

In general within the basin, both for enterprises and for human settlements, the use of drinking water for production needs is constantly decreasing. It should be noted that an increased percentage of drinking water usage is associated with its use in the housing and communal services and food industry.

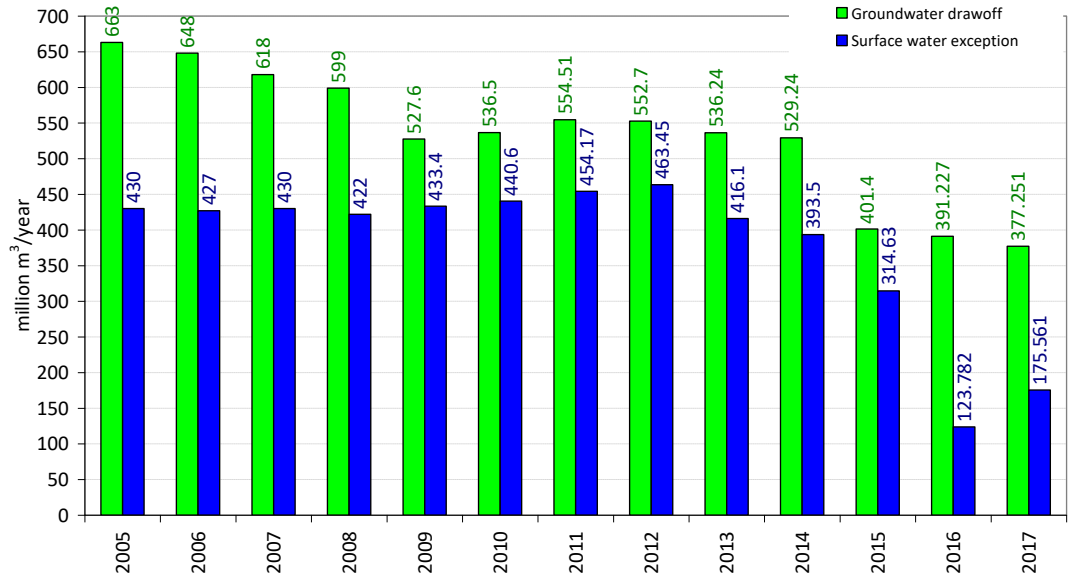

Figure 3.3 – Dynamics of the groundwater extraction and surface waters intake in Dnieper basin

At present, the main problem of providing water of the required quality in rural areas is water conditioning and purification. Basically, groundwater treatment consists of the removal of iron, despite the fact that there is a high content of nitrogen, ammonium, nitrates and other pollutants in a number of water intakes. The development of centralized water supply systems in the countryside is held back, first of all, by economic factors. Therefore, the problems of water supply and water discharge in rural areas necessitate a state water policy that ensures sustainable water use in rural areas and the guaranteed right of present and future generations to water resources, including quality drinking water.

Quantitative changes in water resources are largely determined by the difference between the extraction (production) and the diversion of water, i.e. irretrievable water consumption (in relation to water bodies). At present, irretrievable water use in the Dnieper basin does not exceed 1% of the runoff of 95% of the supply and does not have a significant impact on the quantitative indicators of water resources in the Dnieper basin.

In the Dnieper basin, there are 3479 water intake facilities designed for the extraction of surface waters, 10951 facilities (wells) intended for the extraction of groundwater, of which 3203 are conserved, and 294 are liquidated.

Group water intakes of Minsk, Mogilev, Gomel, Orsha, Svetlogorsk, Borisov, Zhlobin, Rechitsa, Rogachev and other cities are located in the Dnieper river basin.

The actual reduction in the groundwater level of the operated aquifers and complexes for all observed water intakes indicates the availability of water intake within the approved groundwater resources.

Totally, according to the statistical reporting of water use within the State Water Cadastre in the Dnieper Basin, 169 water users are located in Belarus with 308 discharges of sewage into water bodies.

The pervasive substances, the elevated concentrations of which are more often observed in the water bodies of the Dnieper River basin, are biogenic elements, less often - organic substances. The relatively high content of metals (iron, copper, manganese, zinc) is connected with their high natural (or background) content.

The surface water bodies having the greatest anthropogenic load include the Dnieper River below Orsha, Shklov, Mogilyov, Bykhov, Zhlobin, Rechitsa cities; the Berezina River below the Borisov, Bobruisk cities, as well as below the confluence of the river Svisloch; the river Plissa below Zhodino; the Svisloch River

below the discharge of Minsk wastewater treatment plant (WTP); the Uza, Gaina, Rova, Dobysna, Zhadunka, Adrov rivers, and the Milchansk ditch.

Among the reservoirs of the basin, the Osipovichskoye and Chigirinskoe reservoirs, which are affected by the most industrially developed “areas” of the Dnieper River Basin, were subjected to the greatest nutrient load.

A great amount of pollutants enter the Osipovichy reservoir with the waters of the Svisloch River, which is experiencing a significant anthropogenic load from Minsk. This has a negative effect on the state of water in the reservoir. On the banks of the Chigirinsk reservoir there are settlements, recreation and energy facilities, which has a negative impact on the water quality of the reservoir. The Chigirinsk reservoir receives water from the Drut river, on the catchment area of which industrial centers and agricultural facilities are also located.

The major part of the pollutants in the water bodies of the basin comes from point and diffuses sources of pollution. Moreover, the share of diffuse sources within the basin can vary up to 40% for total nitrogen and up to 80% for total phosphorus (up to 25% and up to 79%, respectively, according to data for 2017).

The problem is the lack of biological treatment facilities in many urban-type settlements. The problem is that the wastewater of the meat and dairy industry, discharged without treatment into the municipal sewage system and into the filtration fields.

A significant amount of pollutants enters the water bodies of the Dnieper River Basin with surface wastewater from the territories of settlements within the basin.

In Minsk, the land drainage from the territory of the city, including the industrial zone, falls into the runoff water system, represented by large main collectors with outlets, where they monitor the quality of wastewater. Within the territory of the city there is significant amount of medium and small collectors with outlets in almost all water bodies. And the control on the quality of wastewater is not carried out. In Gomel and Mogilev, the release of runoff from most rain collectors is also carried out into surface water bodies without treatment.

The main problem associated with the operation of industrial water supply systems is a large proportion of outmoded equipment and facilities.

In the Dnieper basin the level of provision with centralized water supply, especially for the rural population, is insufficient. The proportion of sources of decentralized drinking water (as a rule, they are mine wells) according to the State Sanitary Inspectorate, which does not meet sanitary standards in 2017 reached 2% in the Vitebsk region, 2.2% in the Mogilev region, 9.6% in the Gomel region , 2.2% in the Minsk region.

An analysis of the dynamics of the wastewater flow into the water bodies of the Dnieper River basin over the period since 2005 shows a reducing in the volume of wastewater and the share of insufficiently treated wastewater (Figure 3.4). Despite the fact that insufficiently treated wastewater is less than 1%, the load of pollutants on water bodies is significant.

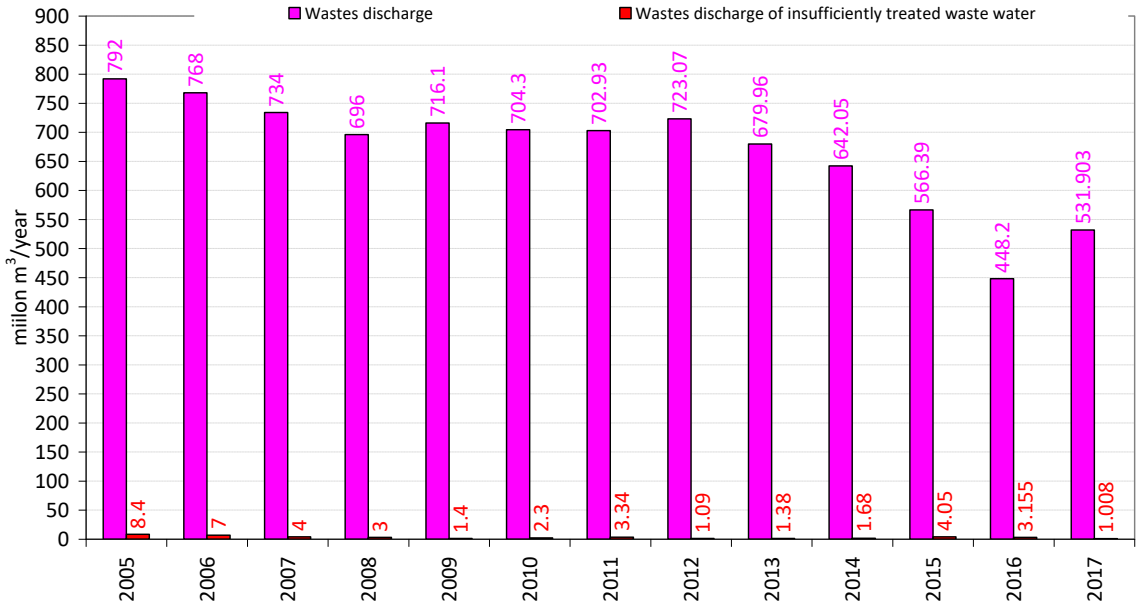

Figure 3.4 – Dynamics of wastewater discharges into surface water bodies in the Dnieper basin and volumes of insufficiently treated wastewater

A dynamics of pollutants decrease flowing into water bodies along with wastewater discharges in the Dnieper Basin on the territory of Belarus (Figures 3.5, 3.6). Exceptions are the components of phosphorus.

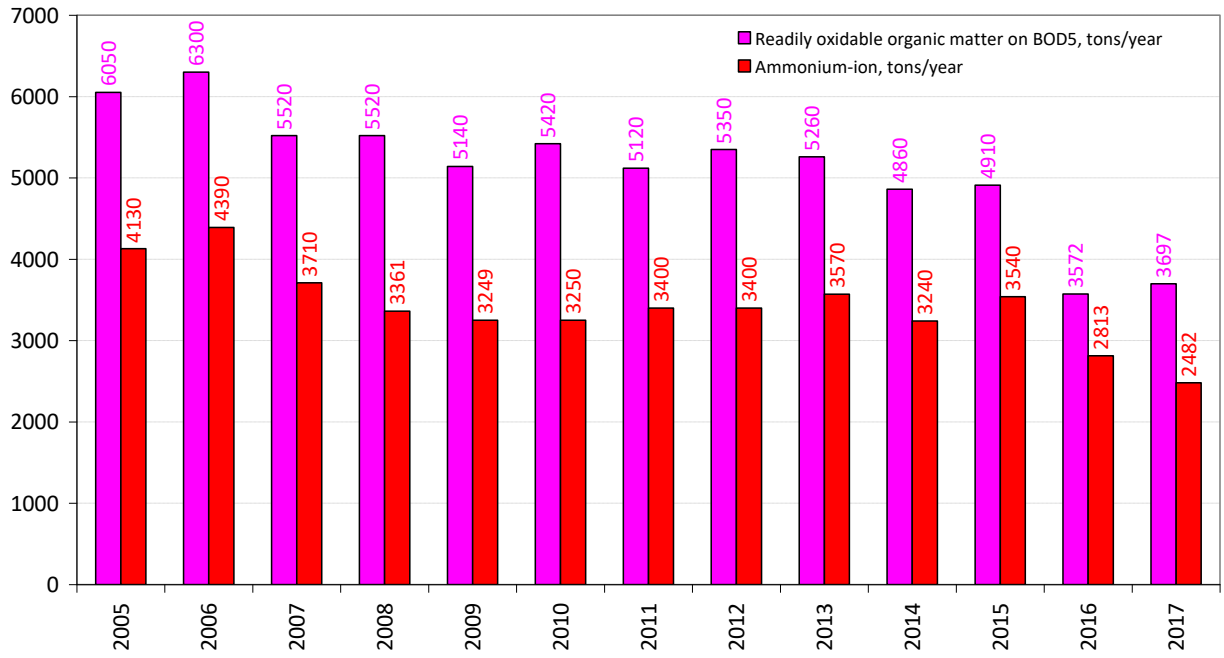

Figure 3.5 – Dynamics of the amount of major pervasive pollutants flowing into the water bodies of the Dnieper Basin

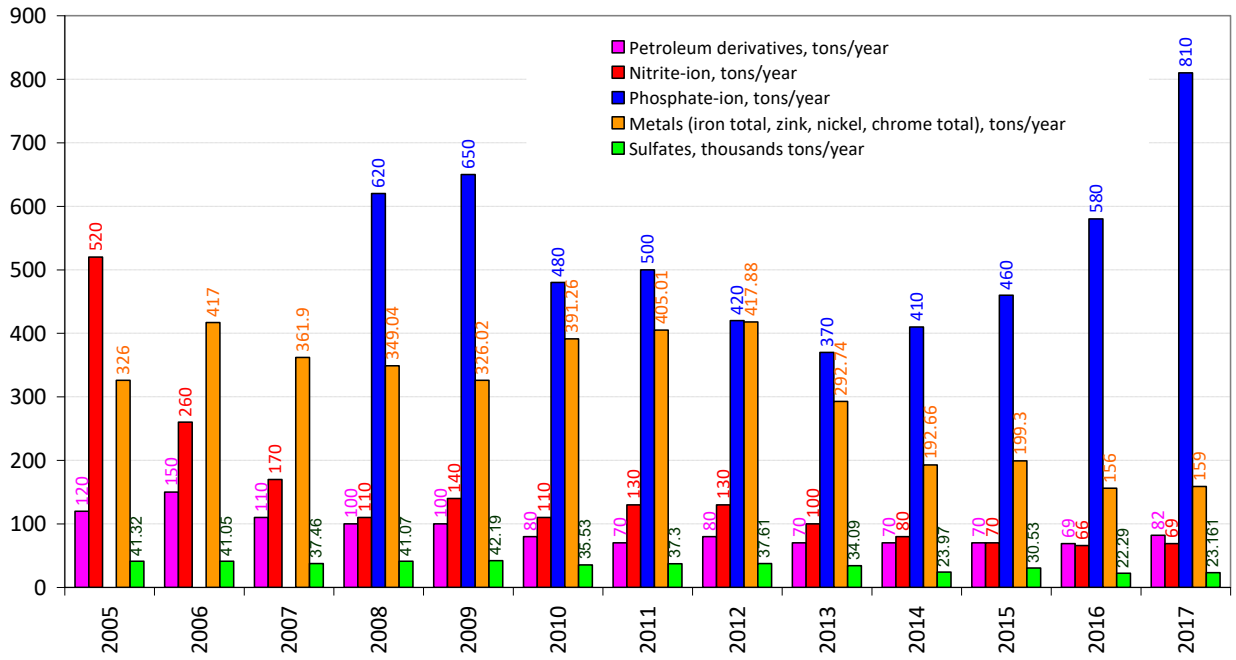

Figure 3.6 – Dynamics of the amount of major pervasive pollutants flowing into the water bodies of the Dnieper Basin

The main sources of wastewater pollutants are Orsha, Mogilev, Rechitsa, Borisov, Minsk, Gomel, Bobruisk cities and other industrialized urban areas. They make up about 60% of the total discharged treated wastewater. The largest contribution (about 40%) is made by the Minsk Wastewater Treatment Plant (MWTP), where wastewater from the population and industry of Minsk is being treated. The MWTP have been operated since 1963. In 2016–2018, a draft program was developed for the modernization and reconstruction of the Minsk Wastewater Treatment Plant.

The greatest amount of sewage and containing pollutants is diverted to water bodies by enterprises of housing and communal services with a volume of more than 5000 thousand m^3/year: "Minskvodokanal", "Gomelvodokanal", Mogilev "Gorvodokanal", Bobruisk, "Vodokanal", "Orshavodokanal."

General information on the treatment plant as of 2017 is given in Table 3.1.

Table 3.1 – General information on the treatment plant in the Dnieper river basin

Characteristic	Value
Amount of wastewater treatment plants providing for the discharge of sewage into the environment (in total)	670
Estimated output of wastewater treatment plants providing for the discharge of sewage into the environment, million m^3/year	1125.856
Degree of loading of wastewater treatment plants, which include discharge of sewage into the environment, %	50.64
Annual estimated output of wastewater treatment plants with the use of artificial biological purification, providing discharge of sewage into surface water bodies, million m^3	777.105
Number of treatment facilities using artificial biological treatment, providing for the discharge of sewage into surface water bodies	62

Characteristic	Value
Degree of loading of wastewater treatment plants with the use of artificial biological purification, providing discharge of sewage into surface water bodies, %	41.74
Estimated output of wastewater treatment plants with the use of mechanical purification, providing discharge of sewage into surface water bodies, million m^3/year	257.227
Number of treatment facilities with the use of mechanical purification, providing for the discharge of sewage into surface water bodies	79
Estimated output of wastewater treatment plants with the use of physical and chemical purification, providing for the discharge of sewage into surface water bodies, million m^3	13.307
Number of treatment facilities with the use of physical and chemical purification, providing for the discharge of sewage into surface water bodies	11
Number of wastewater treatment plants of runoff water system for discharge into surface water bodies	85
Number of treatment facilities with the use of filtration fields, which include discharge of sewage into the environment	479
Number of treatment facilities with the use of filtration fields, with the release of waste water	225
Area of filtration fields, hectares	1523
Annual estimated output of filtration fields, million m^3/year	49.905
Degree of loading of treatment facilities with the use of filtration fields, %	36.8

5.2 Impact assessment of point sources of pollution

Among all water users, 15 enterprises contribute more than 90% of the total wastewater discharge in the basin, the value of which in 2017 reached 531750 thousand m^3 (4484200 thousand m^3 – in 2016, 566390 thousand m^3 – in 2015, 642050 thousand m^3 – in 2014). Whereby the largest contribution (about 38%) is made by the Minsk Wastewater Treatment Plant, where wastewater from the population and industry in Minsk is treated. The location of the main point sources of pollution that have wastewater outlets is given in the map-scheme No.7 of Appendix A.

The generalization of the results of load analysis and impact of point sources of pollution on their releases, which have a significant impact on the hydrochemical indicators of the state of water bodies, taking into account the water content of the receiving water body (its dilution capacity) and local monitoring data above and below the discharge, is given in Table 6 of Appendix A. Among 169 water users, 25 water users have the most significant impact on 29 wastewater outlets.

The most significant point sources of pollution are discharges of wastewater from wastewater treatment plants of housing and communal services and industry. These are enterprises of housing and communal services of Minsk, Zhodino, Borisov, Kostyukovichi, Krichev, Bykhov, Bobruisk, Logoisk, Gomel cities. The most significant contribution is made by the wastewater release from the Minsk Wastewater Treatment Plant, where almost all wastewater from the population and enterprises of Minsk is treated.

Surface water bodies having the greatest anthropogenic load in the result of wastewater discharge are presented in Table 7 of Appendix A. These facilities include the following rivers: the Dnieper below Orsha, Shklov, Mogilev, Bykhov, Zhlobin, Rechytsa cities; the Berezina below Borisov, Bobruisk cities, the confluence of the river Svisloch; the Plissa below Zhodino; the Svisloch River below the discharge of Minsk wastewater treatment plant; the Milchansk ditch; the Uza, Gaina, Rova, Dobysna, Zhadunka, Adrov rivers.

Local monitoring of groundwater is conducted by users of natural resources within locations where objects of adverse impacts are located, such as municipal and industrial waste landfills, sludge banks of treatment facilities, agricultural irrigation fields, filtration fields, industrial sites of enterprises, storage sites for oil products, disposal of unusable pesticides, etc. These objects are both point and diffuse sources of groundwater pollution.

According to the local groundwater monitoring, there is no significant groundwater pollution in areas where industrial sites of enterprises are located.

5.3 Impact assessment of diffuse sources of pollution

Agriculture is the main diffuse source of pollution in the Dnieper basin. The foundation of agricultural activities is agricultural production enterprises or former collective and state farms. There are also private agricultural enterprises focused on growing vegetables, as well as animal husbandry. Within the agrarian territories the main sources of nutrient loading are agricultural lands with the use of mineral and organic fertilizers as well as hayfields, pastures, livestock facilities (premises for cattle, sewage sludge tanks, manure storage tanks and liquid manure tanks), mineral fertilizer depots, rural settlements, and also natural vegetation (forests, meadows, swamps) and atmospheric precipitation.

The main diffuse sources of groundwater pollution are also associated with agricultural activities and waste accumulation. Moreover, industrial and agricultural facilities have the most significant negative impact on shallow unconfined groundwater aquifers.

The total assessment of the contribution of diffuse sources of pollution into the water bodies in the Dnieper basin was carried out using the balance method according to 2017 data based on the information analysis on the water quality in the Dnieper River within the NEMS observation points at transboundary sites above Orsha (inlet from the Russian Federation) and Loev (outlet to Ukraine). At the same time, the hydrological conditions of the year of 2017 (flow characteristics within these sites) and the data on the total discharge of pollutants for nitrogen and phosphorus were taken into account. In fact, the water quality in the river in the lower section of the Dnieper basin near Loev characterizes the contribution of all sources of pollution in the Dnieper basin, and also includes the background pollutants and the non-conservativeness of these pollutants, namely factors associated with the consumption of these pollutants by aquatic organisms, loss to the bottom, maceration etc. (Table 3.2).

Table 3.2 – General assessment of the contribution of point and diffuse sources of pollution in the Dnieper basin (according to data for 2017)

Pollution indicator	The contribution of point sources of pollution		The contribution of diffuse sources of pollution, *including the background pollutants and their non-conservativeness*	
	tons/year	% out of total pollution	tons/year	% out of total pollution
Total nitrogen	4963.39	21.4%	18229.76	78.6%
Total phosphorus	971.00	75.3%	317.72	24.7%

More detailed assessment of the contribution of dispersed (diffuse) sources of pollution was made with the use of statistical data of the National Statistical Committee of the Republic of Belarus for 2017 on the areas

and the most common types of agricultural lands (crops and grain legumes, potato) in the context of administrative districts, taking into account the share of areas of the regions located in the basin of the Dnieper. To make the assessment, data on the application of mineral and organic fertilizers per hectare in the regional context, based on the type of farmland, were used. The level of usage of the main biogenic elements of total nitrogen and phosphorus (as part of P_2O_5) with organic and mineral fertilizers in the Dnieper river basin is presented in Figure 3.6.

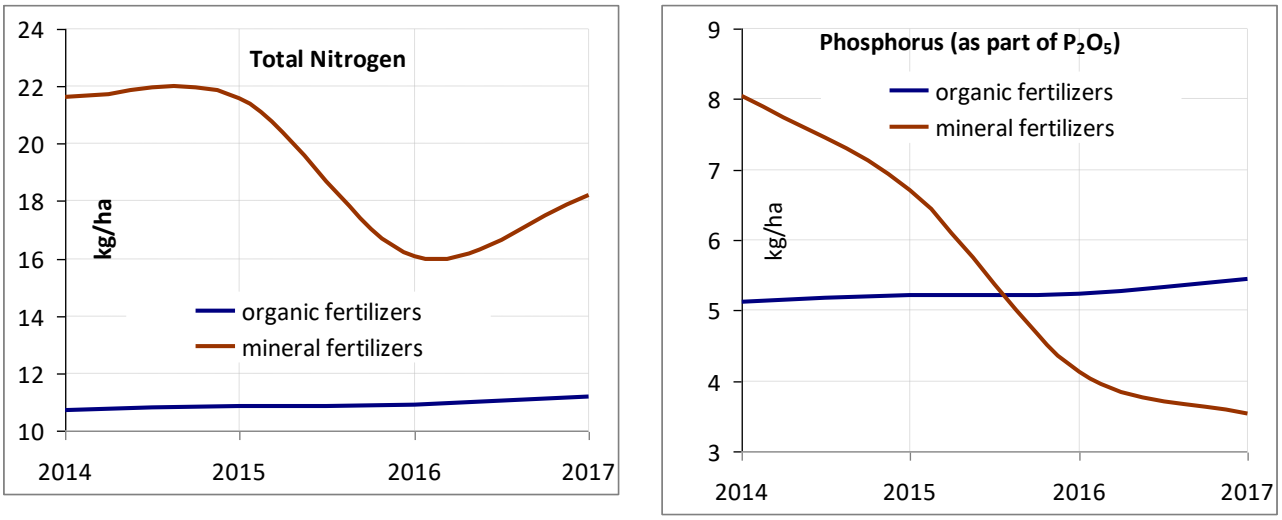

Figure 3.6 - The level of application of the main nutrient elements of total nitrogen and phosphorus (as part of P_2O_5) with organic and mineral fertilizers in the Dnieper River

The given indicators show the total level of application (distribution) of mineral and organic fertilizers in the catchment area of the Dnieper basin. The decrease in the usage of phosphate fertilizers is primarily due to the increase of their prices and partial replacement with organic fertilizers. The load distribution in the Dnieper basin by the amount of nitrogen and phosphorus occurred in the territory in the result of applied mineral and organic fertilizers, according to the data for 2017, is presented in Figure 3.7.

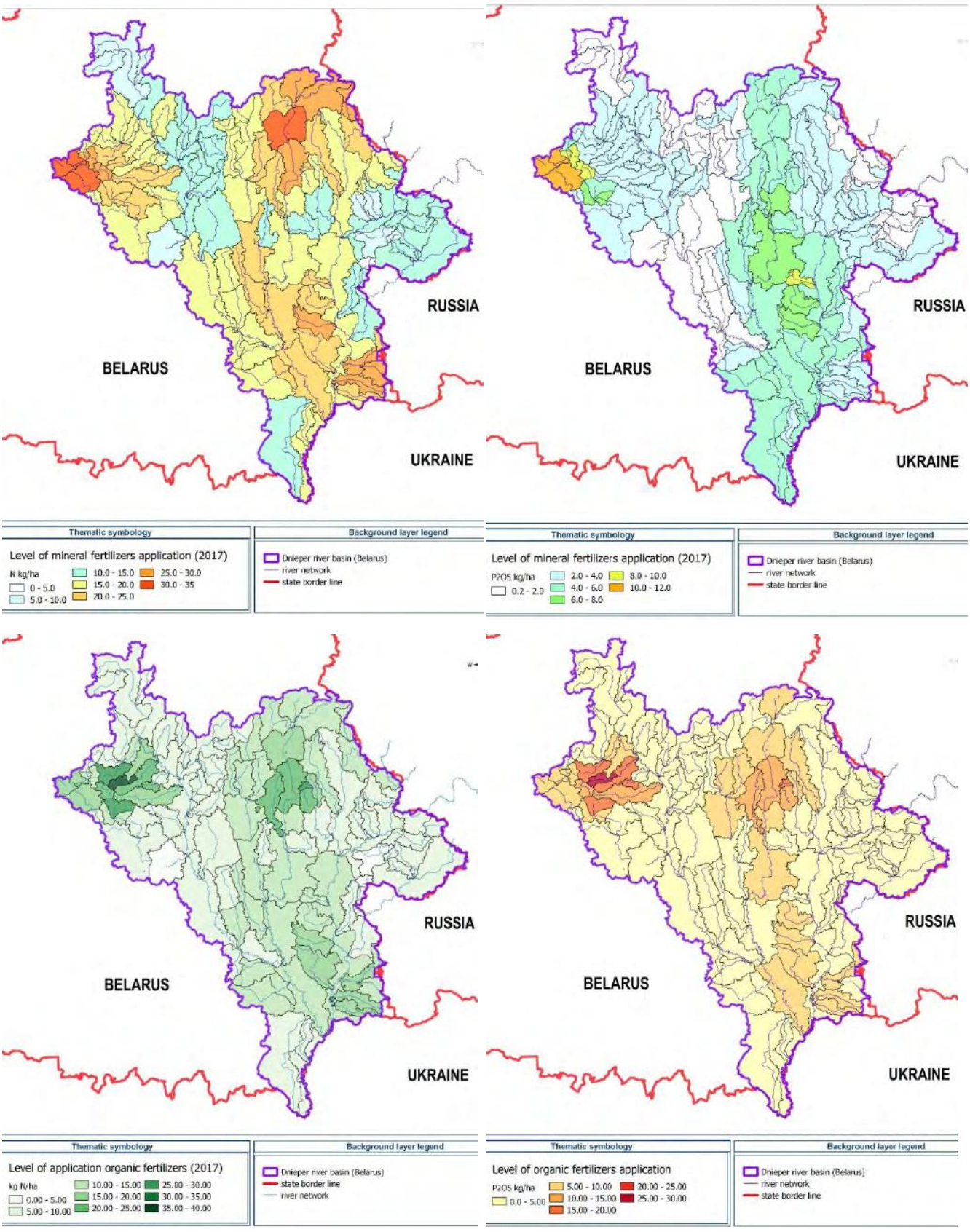

Figure 3.7 – Distribution of the load on the Dnieper basin by the amount of nitrogen and phosphorus formed in the territory from mineral fertilizers (Figures a, b) and organic fertilizers (Figures c, d)

(according to the data for 2017)

The amount of nitrogen and phosphorus (as part of P_2O_5), potentially occurring on the territories of administrative districts — the excess of nitrogen and phosphorus — was calculated with the use of new methodology for assessing pollution from dispersed (diffuse) sources suggested in the framework of the EUWI + project (the dynamics of average changes in the pool is presented in Figure 3.8 and Table 3.3).

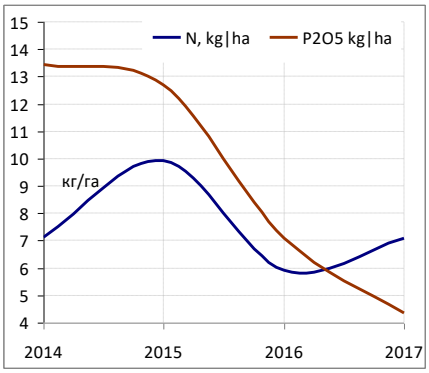

Figure 3.8 – the excess of nitrogen and phosphorus

Table 3.3 – The total amount of organic and mineral fertilizers, as well as the excess value of nitrogen and phosphorus (as part of P_2O_5)

Year	Organic fertilizers		Mineral fertilizers		*Excess*	
	N, tons	P_2O_5, tons	N, tons	P_2O_5, tons	*N, tons*	*P_2O_5, tons*
2014	69610.35	30958.85	140819.23	53108.32	*44515.21*	*85838.49*
2015	69304.89	30996.13	141081.86	44569.66	*65869.32*	*83305.32*
2016	69688.41	31216.95	104249.29	26869.19	*38078.88*	*43701.28*
2017	71513.65	32036.34	120076.89	23344.81	*45671.96*	*27389.90*

Using geospatial analysis, the results of the calculations were corrected to the watersheds of water bodies using the zonal statistics method. The total nitrogen and phosphorus load presented in Figure 3.9 was further used in the assessment of surface water bodies, which are at risk of not achieving good ecological state (status), and presented in section 3.8 below.

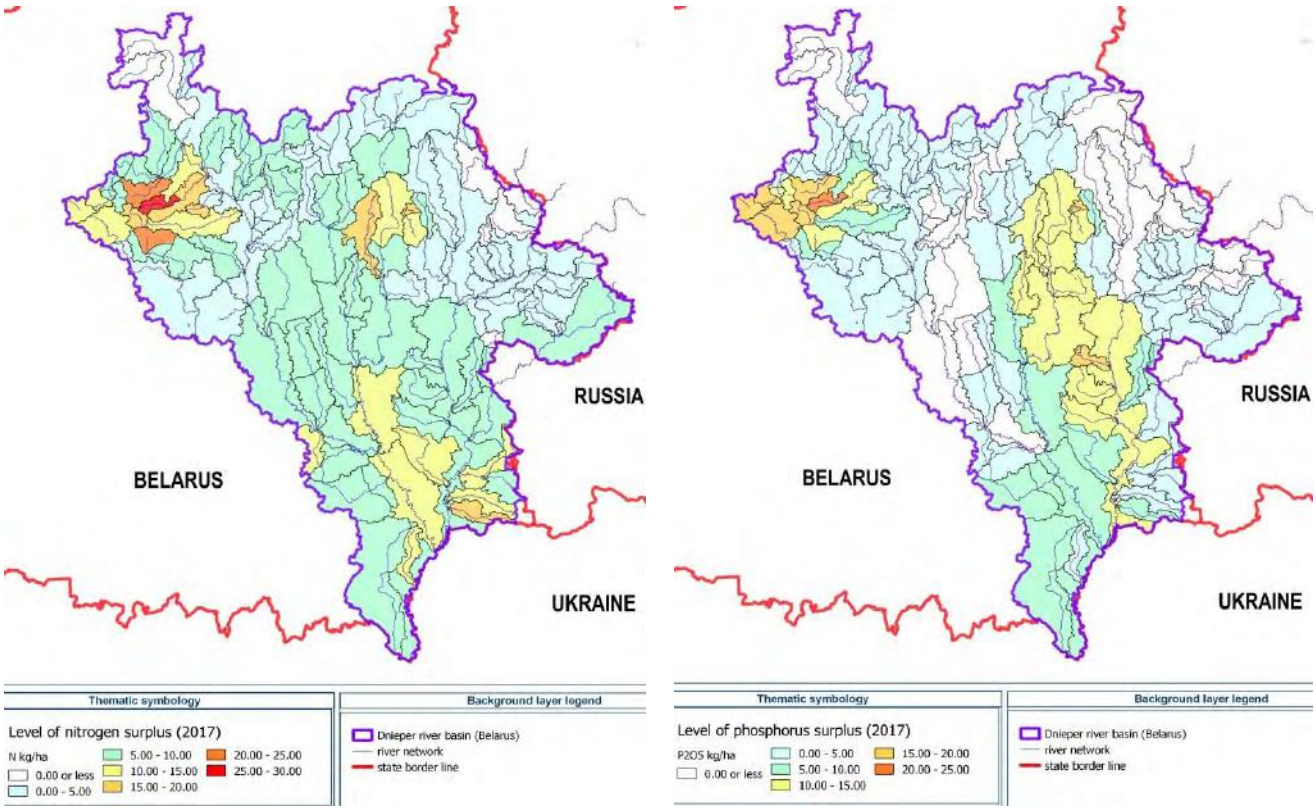

Figure 3.9 – The overall assessment of the formation of total nitrogen and phosphorus

Apart from the distribution of mineral and organic fertilizers in the Dnieper Basin, *the use of pesticides in agriculture can be the potential danger of water bodies' contamination from diffuse sources.* Pollution may be due to the possible formation and spread of pollution zones of the upper aquifer of groundwater within areas where pesticides are used.

Detailed information on the intensity of the use of pesticides (kg per 1 ha of agricultural land) within 108 water bodies in the basin for the period from 2014 to 2017 is given in table 6.4 of Appendix A. Over 4 years, a decrease in the use of pesticides in the Dnieper basin has been revealed (Figure 3.10). The highest level of pesticide use was observed in the water catchment areas located near Minsk. This may also be due to a much greater concentration of greenhouse facilities, since the pesticides can be used for the production of agricultural goods.

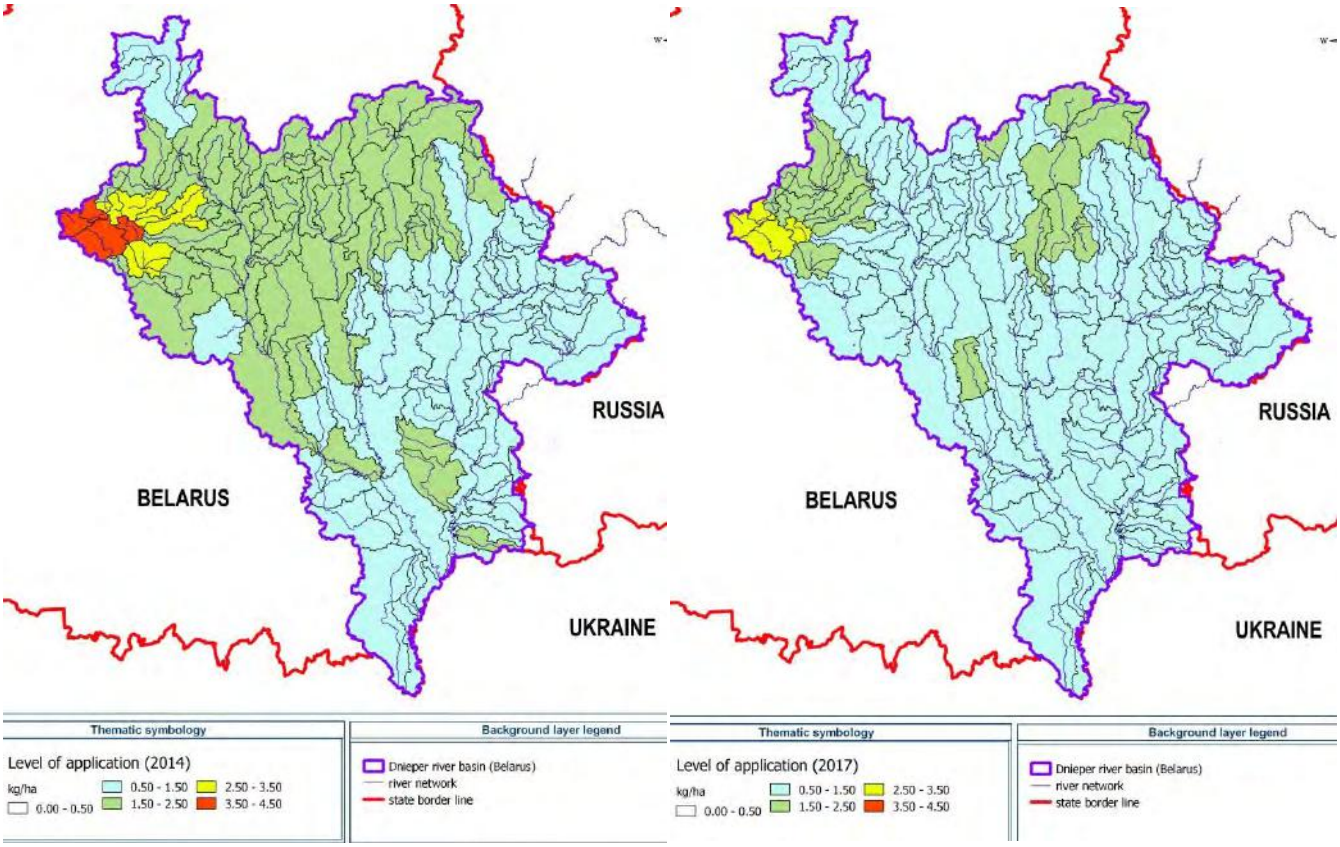

Figure 3.10 – Intensity of pesticide use

5.4 Hydromorphological changes of water bodies3

In the Dnieper basin there are significant hydromorphological changes in surface water bodies associated with the location of objects that disturb the continuity of the river flow, reservoir impacts and straightening of rivers.

General synthesis map of hydromorphological changes of water bodies is given in Appendix B (figure 20).

Table 4.4 of Appendix A provides a list of 46 river areas (Figure 3.11) that are affected by objects that disturb the continuity of the river flow.

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[3] this section is prepared within the framework of EPIRB

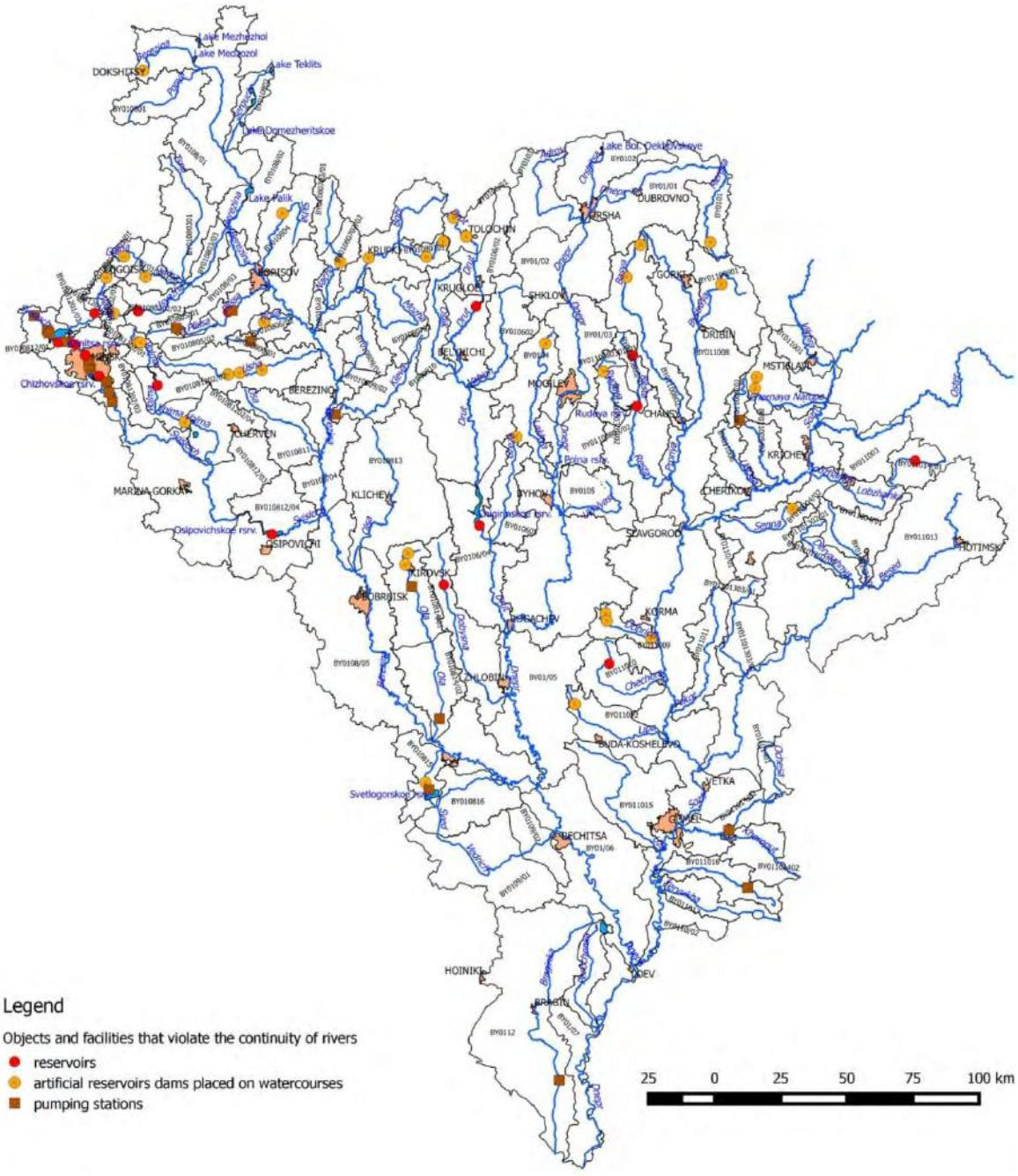


Figure 3.11 – The scheme of location of objects that disturb the continuity of the flow of watercourses

Hydrological changes (reservoir impacts)

The channel reservoirs with a total water volume of more than 1 million m^3 are considered as the main objects influencing the changes in the hydrological regime of a water body. Channel reservoirs can influence the water regime of river stretches both downstream (fluctuation of water levels) and upstream (decrease in water flow rates).

17 channel reservoirs that affect 13 river areas are revealed in the Dnieper River basin (Figure 3.12). Table 4.5 of Appendix A reflects a list of 13 river areas that are influenced by channel reservoirs.

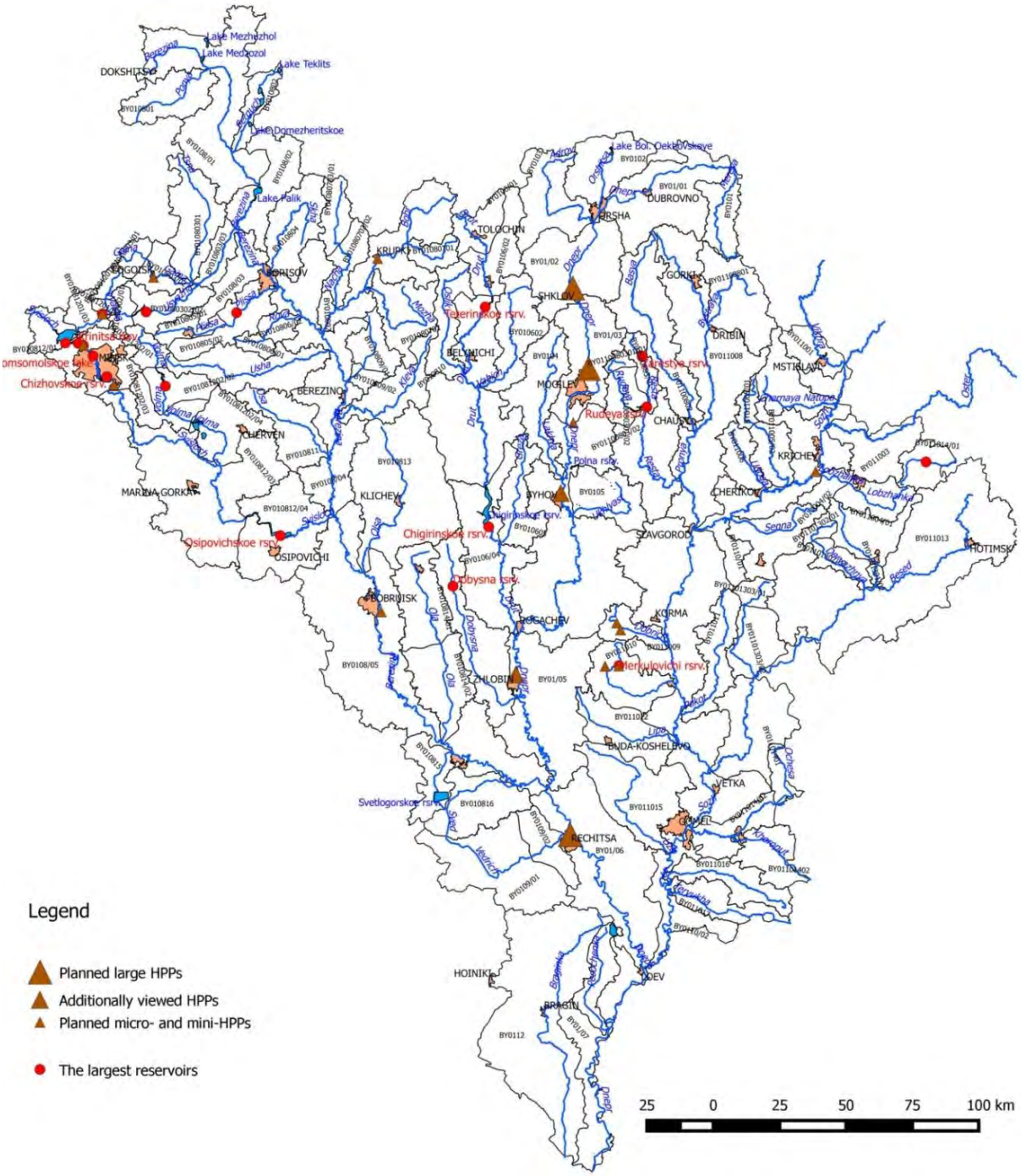


Figure 3.12 – The scheme of location of channel reservoirs that affect the water regime of rivers

River morphology changes (straightening of river beds)

A large-scale reclamation of rivers and channels' straightening was carried out in the Dnieper river basin on the territory of Belarus during the Soviet period. Among 108 considered river areas, 69 had changes in the morphology and channels' straightening (Figure 3.13).

Table 4.6 of Appendix A provides a list of 69 river areas with changed river morphology, ranked by the length of the river that was straightened.

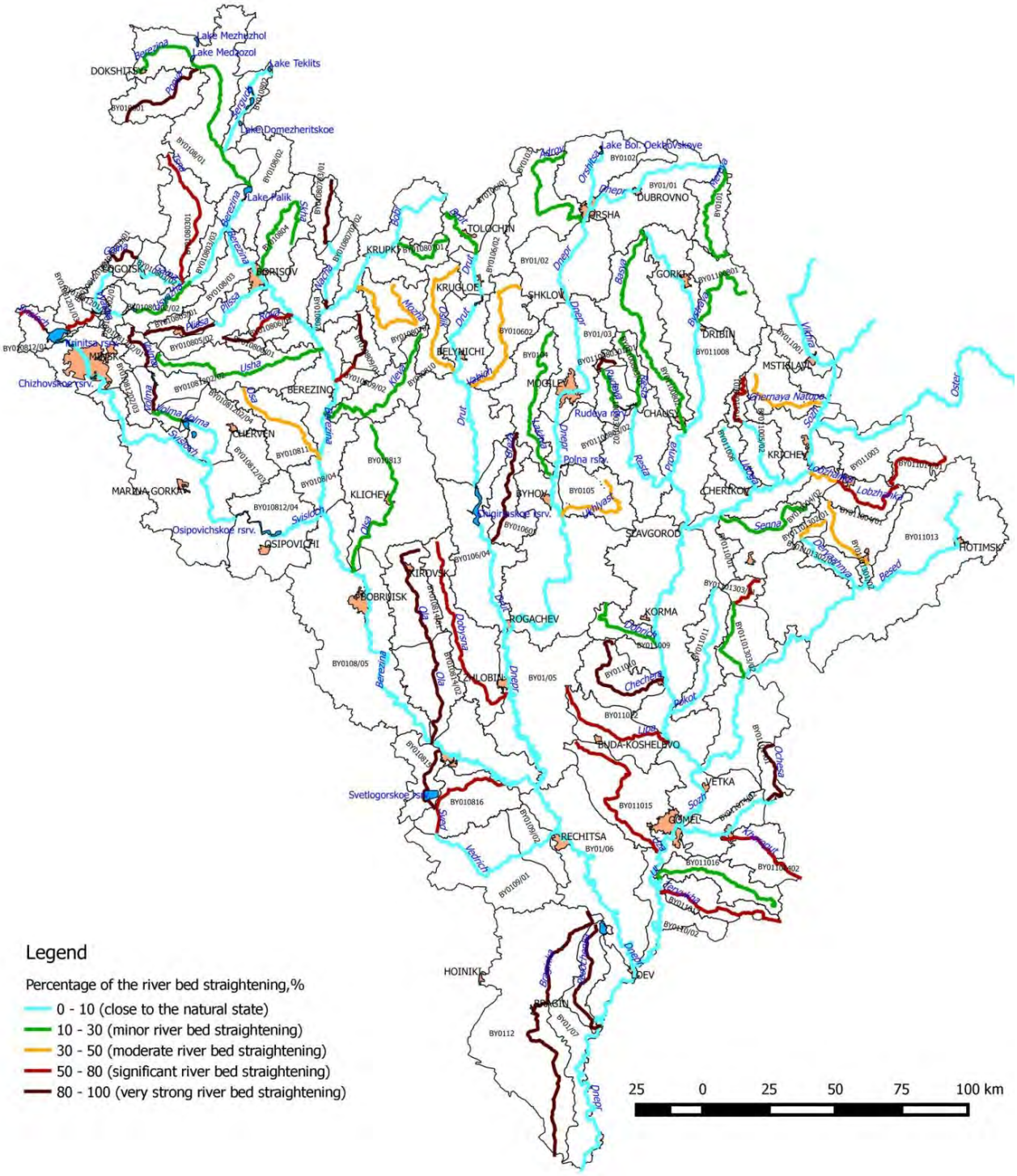


Figure 3.13 – Scheme of location of watercourses and the characteristics of their strengthening

5.5 Other pressures (filtration fields, landfills for municipal and industrial wastes, radioactive contamination, spread of alien species, road infrastructure)

An increasing danger for pollution of surface and groundwater bodies is the wastewater inflow as a result of its flushing by surface and subsurface runoff from filtration fields, which can be considered both point and diffuse sources of pollution. A large number of enterprises use filtration fields with a total area of 1938 hectares as wastewater treatment plants for wastewater disposal. At the same time, in the result of 695 releases in 2017 27.0 million m^3 wastewater was discharged, which is less than 5.1% of the total amount of discharged wastewater in the Dnieper basin. The operated facilities for artificial biological treatment will allow decommissioning the filtration fields in some cities and towns. However, due to the development of agricultural settlements, it is still planned to increase the volume of wastewater discharge to the filtration fields. The filtration field capacity in the Dnieper basin is 100.1 million m^3/year. Detailed information on the wastewater discharge into the environment using filtration fields in the Dnieper basin, updated according to the field surveys of 2017, is presented in Table 6.1 of Appendix A.

Storage and disposal sites (landfills) of industrial and municipal waste, as well as filtration fields are both point and diffuse sources of pollution of surface and groundwater with deterioration in their quality. In the Dnieper river basin 56 landfills of industrial and municipal waste landfills are located (Table 6.3 of Appendix A).

According to the local groundwater monitoring in areas where municipal and industrial waste landfills are located, deterioration of groundwater quality occurs mainly due to an increase in the nutrients' content, primarily ammonium nitrogen and nitrates, as well as salinity (due to sulfates and chlorides) and heavy metals (zinc, chromium, copper), petroleum products.

The constant increase in the economic value of the floodplain territories due to the implementation of land improvement activities, increase in crop yields, development of settlements, transport communications, etc. contribute to the growth of average flood damage. In addition, permanent losses are possible due to the fact that potentially highly productive agricultural lands actually fall out of intensive economic use due to the high probability of flooding. In addition, permanent losses are possible due to the fact that highly productive agricultural lands actually fall out of intensive economic use due to the high probability of flooding.

Radioactive pollution is one of the most significant environmental problems in the Belarusian part of the Dnieper basin. Large basin areas (including agricultural lands, forest lands, river catchments, etc.) were contaminated with radionuclides in the result of the accident at the Chernobyl nuclear power plant (hereinafter referred to as Chernobyl NPP). For this reason, large areas in the Gomel and Mogilev regions in the Dnieper basin were withdrawn from agricultural use.

An analysis of the radioactive contamination of rivers indicates that the radiation situation on monitored water bodies has stabilized. Due to natural processes, the concentrations of cesium-137 and strontium-90 in the water of large and medium-sized rivers decreased significantly. However, for the majority of monitored rivers their activity is above pre-emergency levels.

Studies have shown that a higher content of radionuclides is observed during floods in the rivers, whose catchments are fully or partially located in the 30-km Chernobyl NPP zone. These water bodies require constant observations.

Despite the fact that the average annual content of strontium-90 tends to decrease, there is a periodical increase in its concentrations in the river as a result of its flushing with melt and rainwater from the catchment area.

Now, the main transboundary transportation of cesium-137 and strontium-90 is caused by their removal due to the washing-off of radionuclides from the exclusion zone. The major danger is represented by small reservoirs and closed lakes located within the Dnieper catchment territory, where the levels of cesium-137 and strontium-90 may exceed the current standards.

The immigration and invasion of alien (invasive) species can have a negative impact on the environment. The number of alien species entering the territory of Belarus is increasing rapidly. Among the invasive plant species that are most dangerous, we can distinguish the Sosnovski and Common ragweed (appeared in southern Belarus, up to 80% of the population is allergic to its pollen in those Ukrainian regions where it has widely spread).

According to the data of the Research and Production Center for biological resources, there are 63 species of fish in Belarus. And more than 40 of them belong to the aboriginal species (originally living within this area). Among them roach, perch, bream, pike, tench, crucian carp and others are occurring. However, in recent years, the number of foreign (invasive) fish in the rivers and reservoirs in Belarus has significantly increased. Only in two years in the country five new species of fish have been identified, including tube-nosed goby, Ukrainian small stickleback, white-finned gudgeon, and golden mudfish. In addition, such foreign species as silver carp and Amur sleeper are widespread in Belarus. They adapt well to the conditions of the rivers and reservoirs of the republic, quickly multiply and constitute a serious competition to representatives of the indigenous fish fauna of the republic. To a large extent, the climate warming contributes to the spread of invasive fish species throughout Belarus. To make a conclusion about the impact of the foreign species of flora and fauna on the ecological state of the Dnieper basin is problematic because of the lack of relevant information.

Such economic branches as *fish farming, forestry, hydropower, shipping, tourism, transport and the road network, main oil pipelines and product pipelines, as well as recreational use of water bodies (although there are significant excess recreational loads within a number of active recreation areas) do not have a significant impact on the ecological state of water bodies in the Dnieper basin.*

Within many settlements, the boundaries of water protection zones and coastal areas of water bodies are established without taking into account the existing buildings. Often there are livestock farms that have a negative impact on water resources within water protection zones.

5.6 Other pressures associated with hydrometeorological dangerous phenomena, including climate change and possible changes in anthropogenic pressure4

There may be other possible pressures besides the main pressures and their effects on surface water bodies associated with existing anthropogenic activities, based on the possibilities and directions of development of territories in the Dnieper basin. These pressures and their impacts may be due to possible changes in anthropogenic activities, as a result of social and economic development in the Dnieper basin, dangerous hydrometeorological phenomena, as well as climate change (Table 4.7 of Appendix A). The schematic map 11 of Appendix B shows the results of the expected change in the average annual river flow of the Dnieper basin, taking into account the CMIP5 multi-model ensemble for four scenarios presented in the fifth report by the Intergovernmental experts group on climate[5].

[4] The results of the EPIRB-Project were used for preparation of this section

[5] Atlas of Global and Regional Climate Projections// 5th IPCC-Report, p. 1350 – 1353: http://www.ipcc.ch/report/ar5/wg1/

5.6.1 Floods

Floods are understood as the flooding of a territory as a result of a rise of the water level in a river or lake, which causes material damage, damages the health of the population or leads to the death of people. Floods, which are the result of spring high waters and rain floods, are one of the natural disasters in terms of frequency, coverage of territories and material damage. The increase in losses caused by flooding is also associated with an increase in the intensity and frequency of floods due to increased economic use of catchment areas, river valleys and flood plains.

The Dnieper basin is characterized by the occurrence of both spring floods and rainfalls.

In the Dnieper basin on the Dnieper, Sozh and Berezina rivers, as a rule, high water flows in one wave[6]. During the prolonged (interrupted) nature of snowmelt in the lower streams of the Sozh, Berezina and Dnieper below Mogilev, spring floods consist of several waves. In the upper streams of these rivers, where the thaws are less prolonged and intensive, only quite low winter floods are formed. In the Dnieper upper streams within the area "rise - Orsha", the height of the spring maximum levels due to the high rates of slope flow of thawing water is much greater than in the downstream. Within the Sozh and Berezina rivers, the height of the level increases downstream. In the lower streams of the Sozh and Dnieper, spring floods are usually preceded by high levels. And in years with more significant thaws, winter floods are formed due to the intensive thawing of snow and rains. The nature of the falling of the level and its duration depends on the height of the flood and on the amount of precipitation falling during the period of recession. In this case the falling slows down or completely stops, giving way to a rise.

The data, which is preserved from ancient times, shows that catastrophic floods were often formed in the Dnieper river basin. So, for example, as recorded in the literary sources, very high floods in the city of Mogilev were observed in 1709, 1760, 1845 and 1931 years. Flood in 1931 is the most prominent for the entire historical period, preceding the high water of 1845. The maximum level recorded in the city of Mogilev was 835 cm above the zero of the post.

In general, it is typical for the Dnieper river basin that flood occurs within most rivers during the spring flood. Moreover, the width, depth and duration of overflows, depending on the height of the flood, as well as the structure of the channel, floodplain and banks, vary greatly within different rivers, as well as along the length of individual rivers.

Within small rivers, the stand of water on floodplains on average lasts 25–30 days, within medium and large river the stand of the water is about 1.5–2 months. Within most rivers the prevailing width of spills is 1.5–2.0 km, the largest (8–15 km) is observed within the Dnieper below Zhlobin.

For the basins of the Berezina and Sozh rivers (the main tributaries of the Dnieper River) flooding of the floodplains is observed almost annually, the duration of overflows is 8–12 days. The width of overflows here is on the average 0.3–3 km, the depth of floodplain flooding is 0.5–1.0 km.

In the spring the longest floodplains in the Dnieper basin were observed in 1956, 1958, 1962, 1970 and 1979 years. The last significant flood was in 1999.

Rainfalls in summer and autumn occur almost annually. Flood of floodplains in the period of rainfalls are observed less often, and the duration of stand of water within the floodplain is much shorter than during the spring high water period. On the rivers of the Dnieper Basin, there is no tendency for increasing or decreasing the maximum water discharge of rainwater.

[6] Water resources of Belarus and their forecast with account to climate change/ Monograph/ Edited by A.A.Volchak, V.N.Korneev. – Brest: Alternativa, 2017. – 228 p.

Within the Dnieper River in the period from the end of the XIX century and up to the 30-ies of the XX century floods of considerable magnitude were noted (the largest in the alignment of Orsha in 1927). The period from the mid-60's to the mid-80's of the last century is the period with the least amount of rainfalls. A very large rain flood on the Dnieper was recorded in 1962. Since the second half of the 80's of the XX century the magnitude of floods increased. Significant rainfalls were noted in 1991, 1998, 2006, 2008, 2009 years. The largest rainfalls on the Berezina River (Borisov) were in 1927, 1937, 1952 and 1962. The largest rainfalls on the Sozh River were in the first half of the 20th century, the flood of 1933 is particularly significant. In the period from the mid-60's to the 90's of the XX century the amount of rainfall has decreased significantly. Among the large floods of recent decades, one can outline the floods of 1998, 2005, 2006 and 2009. Within the tributaries of the Sozh (the Uza River and Besed River), there is a tendency of decreasing the maximum water discharge of rainfall. Within both rivers, the greatest floods were recorded in the 1930s, and the floods of 1958, 1969 and 1974 were also distinguished by their magnitude. On the Svisloch River, near Terebuty village, the greatest floods were recorded in 1937, 1962, 1975, 1982, 1998 and 2005 (maximum), on the Zhadunka River in Kostyukovichi the greatest floods were observed in 1953, 1958 and 1974 [4].

One of the most important factors determining the possibility of using floodplain areas is the degree of flood risk (Appendix B, figure 19).

Part of the territory of Dobrush, located in the basins of the rivers Iput and Horoput, is chiefly vulnerable to flood risk. Appendix B shows the main results of the pilot project “Analysis and Mapping of Flood Risk in the Dnieper Basin, including the identification of areas most at risk, field studies of hazardous areas, mapping and preparation of a preliminary composition of protective measures using the example of Dobrush, Gomel Region”, carried out within the framework of the EPIRB project.

5.6.2 Low-water seasons

The average duration of the summer-autumn low water period, where the minimum run-off within small and medium rivers can be observed, is up to 140 – 165 days, within large ones is 87 (for example, the Dnieper River near Rechitsa). The shallow low-water winter period, where the minimum runoff can also be observed, occurs mainly in February and March. Its duration within small and medium rivers is up to 60 days; on large rivers it is up to 70 days.

In the most shallow periods on some small rivers, there may be no runoff both in summer (drying up of rivers) and in winter (freezing of rivers) periods. During the low-water period, there is a lack of water for use in industry, agriculture (especially to ensure melioration systems in bilateral regulation of the water regime). Low levels, decreasing depths in rivers complicate river navigation.

The study of perennial fluctuations in summer-autumn and winter minimum water discharge shows the presence of positive and negative trends. For most rivers in the Dnieper basin, there is an irrelevant tendency to increase summer-autumn and winter minimum water flow, and within most of the rivers the gradient of the change in runoff in winter is greater than in summer-autumn period[4]. A larger increase in the winter minimum runoff is chiefly occurring due to climatic factors. The revealed changes in the winter minimum runoff may be due to the general trend of climate warming and, in particular, to the increase in the number of thaws in the winter. Regularly observed periods of temporary decrease and increase in water content of rivers are associated with changes in climate (precipitation, air temperature) caused by the planetary reasons (general circulation of the atmosphere).

However, despite these positive trends in the change of the minimum runoff, due to climate change, there is a probability of occurrence of hazardous hydrometeorological phenomena associated with droughts, which can lead to low-water and especially low-water periods. It should be noted that in recent decades a particularly shallow period has been observed in Belarus in 2015, including the Dnieper basin, when water levels in some areas of the watercourses were below the minimum observed over the entire observation period. The period of 2016 was also shallow.

The possible reduction of surface runoff in low-water periods as a result of climate change can lead to a deterioration of the ecological state and recreational potential of surface water bodies (especially small rivers) and adjacent territories (changes in the hydrogeological regime of groundwater, depletion of soil cover in the floodplain, etc.). In addition to economic damage (mainly for agriculture), this can lead to the threat of water supply safety in rural settlements that are not connected with centralized water supply systems, due to lower groundwater levels and shallowing of wells.

5.6.3 Erosion processes

Erosion processes do not have a significant impact on their ecological state for the rivers of the Dnieper basin. Natural processes of free and limited meandering predominate on rivers, in some areas incomplete meandering and a side type occur. Changes of the coastal area due to erosion processes and channel deformations within the transboundary areas of the Sozh and Dnepr rivers are mostly characterized for the right (Belarusian) shore.

5.7 Risk analysis

5.7.1 Results of the research on perspective use of water resources

Perspective use of water resources should be carried out in accordance with the Water Code of the Republic of Belarus to achieve the goals set by the National Strategy for Sustainable Socio-Economic Development of the Republic of Belarus for the Period up to 2030 (NSSD-2030) and the Water Strategy of the Republic of Belarus for the Period to 2020.

The national strategy for sustainable social economic development of the Republic of Belarus for the period until 2030 in the field of sustainable use of natural resources and the protection of biodiversity states that the main challenges to the sustainable development of the world economy are the threat of global climate change and reduction of biodiversity, the risk of disturbances in the ecological balance and water balance of territories. Taking into account the high assessment of the possibility and scale of the consequences of global risks associated with the increasing scarcity of quality water resources in the world, the strategic goal of conserving water resources in Belarus is to increase the efficiency of the use and protection of water resources, improve their quality in accordance with society's needs and possible climate change.

To achieve this objective, the environmental policy of the Republic of Belarus should focus on minimizing of pollution of surface water bodies by sewage, thawed and rainwater, restoration of disturbed aquatic ecosystems, assessing the impact of possible climate change on water resources, effective environmental education of the population.

The main objectives of the Water Strategy of the Republic of Belarus for the period until 2020 are the achievement of a good status of surface water by reducing the flow of dispersed sewage into water ecosystems, reducing the negative consequences of floods and droughts by restoring the hydrological regime, expanding the use of water bodies for recreational purposes including the development of ecological tourism and agro-tourism, the formation of tourism infrastructure, sustainable use of biological resources at the local level.

The characteristics of the future use of water resources are based on data on surface water bodies provided for separate water use and for rent (Table 15 of Appendix A), information on groundwater intake (Table 14.2 of Appendix A), places of surface water bodies

used for recreation, sports and tourism (Table 19 of Appendix A), as well as information on the social economic development of the Dnieper River Basin and the management systems for the use and protection of water bodies.

The basis for the assessment of future use is a water use estimation, which is made using water use analysis according to SWK (State Water Cadastre), hydrological data, as well as the information listed above. The data from the National Statistical Committee of the Republic of Belarus on the estimation of the population living in the basin, changes in the ratios between the urban and rural populations, as well as forecast indicators of the economic development of the republic were used.

The main estimated indicators and measures are given in the Social Economic Development Program (SEDP) of the Republic of Belarus for 2016-2020. The basis of the system development of the relevant regions is also the program of social economic development of regions, districts and cities of regional subordination.

According to the SEDP, as applied to the Dnieper basin in the Vitebsk region, the modernization of the “Orsha Linen Combine” enterprise will be done, and the realization of a number of landmark projects will be completed in the Gomel region. Among them, the reconstruction of the main technological units of electric steel-making shops No.1 and 2, the construction of a complex of special steels at OJSC “Belarusian Metallurgical Plant” – the managing company of the “Belarusian Metallurgical Company” holding, the Plant of the production of a bleached sulphate pulp on the basis of OJSC “Svetlogorsk Pulp and Cardboard Plant” with capacity of 400 thousand tons per year on "turnkey" basis, technical re-equipment of the branch "Dobrush paper factory" Hero of Labor "of OJSC" Management Company holding "Belarusian wallpapers" with the organization of the production of coated and uncoated types of cardboard on "turnkey" basis. In the Minsk region, the key projects will be the construction of the Industrial Park “Velikiy Kamen”, as well as the mining and processing plant in the Luban district (IOOO “Slavkali”), a plant for the production of passenger cars of CJSC “Beldzhi”, a new milk processing plant (OOO Nesvizh Plant of Child Nutition“), a transport and logistics complex on the territory of the FEZ “Minsk” (free economic zone). The reconstruction of ampoule production at the OJSC “Borisov Medical Preparations” will be done.

In the Mogilev region, it is planned to reconstruct production facilities for the production of rubber goods in Krichev with an increase in the production of polyvinyl chloride model shoes to 250 thousand pairs per year, to make a technical re-equipment of the four food production organizations, to build a complex for the production of polyester products at OJSC “Mogilevkhimvolokno”, expand the production of broiler chicken meat in the branch of Servolux Agro, CJSC Servolux, to modernize the foundry and mechanical processing equipment of OJSC “Bobruysky Machine Building Plant".

The six-year period which precedes the start of the implementation of the RBMP from 2012 to 2018 with a assessment for the first cycle of the implementation of the RBMP from 2019 to 2024, which is also six years, was taken as the basic level for assessing the prospective use of water resources.

The determination of the future needs of the industry in water is based on an evaluation of the estimated production volume taking into account the reduction rate resulting from the use of water-saving technologies and specific indicators of water consumption per unit of production (the index of industrial output for the future is 109–110%). The indicators of the surface water use for agricultural production are determined by taking into account the index of agricultural production (107–108% per year) and the smoothing coefficient of the secondary water factor in increasing the volume of production in the industry. The water needs of communal services are determined taking into account the estimated urban population and specific indicators of water consumption per inhabitant which have a tendency to decrease.

By the end of the estimated period, a slight decrease in fresh water consumption for industrial needs is expected, but the rate of this decrease will significantly reduce. This is due to the influence of various factors on the dynamics of water use. On the one hand, an increase in industrial production and expansion of the construction industry is expected, on the other hand, it is estimated that water saving trends and recycling and re-systematic water supply systems will increase.

In the housing and communal sector, despite changes in the ratios between the number of urban and rural population towards the urban, due to scientific and technological progress, preventing leaks and wasteful water consumption, irretrievable water consumption will decrease in the Dnieper basin over the forecast period by 3.5–4.0 %

The estimation of the volumes of wastewater use and disposal was based on the fact that the use and disposal of wastewater has decreased in recent years by 3–15% per year. The decrease is associated with the implementation of instrumental metering of water use and an increase in water saving trends in the housing and communal and industrial sectors.

The dynamics of possible impacts on water resources will depend mainly on the water use technology, the application of water saving and water protection measures and the development of the economy.

Taking into account the necessity to solve the identified issues and estimated water consumption and drainage in the basin, measures are planned to achieve the goals set to improve water use and improve the ecological status of water bodies. In accordance with these measures, the network of centralized water supply will be expanded, and drinking water will be reduced to standard quality. Due to the reconstruction of worn water supply networks, water losses will also decrease. Improvement of water use technology, transfer of industrial enterprises for recycling and re-systematic water supply will improve the state of water resources and prevent deterioration of their quality characteristics.

The commissioned facilities for artificial biological treatment will allow the decommissioning the filtration fields in some cities and towns. However, due to the development of agricultural settlement, it is still planned to increase the volume of wastewater discharge to the filtration fields.

An increase in the volume of wastewater that does not require additional treatment is planned within heat and power facilities due to the implementation of direct flow water supply schemes, as well as possible climatic features of the year. An increase in the volume of wastewater of this category is also planned in connection with the commissioning of deferrization stations in some cities.

The impossibility of achieving a 100% degree of regulatory cleaning of the entire volume of polluted wastewater is still due to the high physical deterioration of facilities and equipment, the necessity to remove them from the treatment process, and overload of treatment facilities.

The key point when forecasting water use is the transfer of a part of the Viliya river basin flow along the Vileyka-Minsk water system (WMWS) to provide water to Minsk and the watering of the Svisloch river, which the most intense water artery of Belarus by the quantitative and qualitative characteristics of the water regime (Figures 5.1, 5.2). The transfer of runoff from the Viliya river basin through the WMWS to the Dnieper basin for conditions of average year of the water content is not more than 20% of the runoff of the Viliya river near Vileyka and not more than 9% of the entire Viliya river basin (not more than 20% for the low-water year). This ranges from 0.1% to 0.4% of the flow of the Dnieper basin within Belarus for an average year of the water content (not more than 3.3% for a low-water year).

The acquired data indicate that due to the current mode of releases from the Zaslavl reservoir (taking into account the operation of the Vileyka-Minsk water system), there is a shortage of water at the exit from Minsk in the annual section and in the summer periods, since the required water supply is not maintained, i.e. design capacity of the Vileyka-Minsk water system is used less than 50%. Visible excess flow occurs only after

the inflow of waste water in the areas of the river below the Minsk aeration station. As a result, runoff outside the city of Minsk consists of 42–67% of treated municipal wastewater.

According to the General Layout of Minsk (review), approved on September 16, 2016 (point 5.3, p.57)[7], it is planned to ensure water supply for the flooding of the Svisloch River and the Slepiansk water system by transfer the flow through the Vileyka-Minsk water system. The volume for the Svisloch River can reach 2.0 m^3/s, and 1.2 m^3/s for the Slepianskaya water system. Summarily it is more than one and a half times as much as the existing flow volumes directed to watering.

It is planned to transfer the entire water supply of Minsk to underground sources. Thus, due to the "retrievable" volumes of water, it will be possible to more effectively meet the indicated requirements for flooding the Svisloch River without a significant increase in the volume of transfer of runoff through the WMWS.

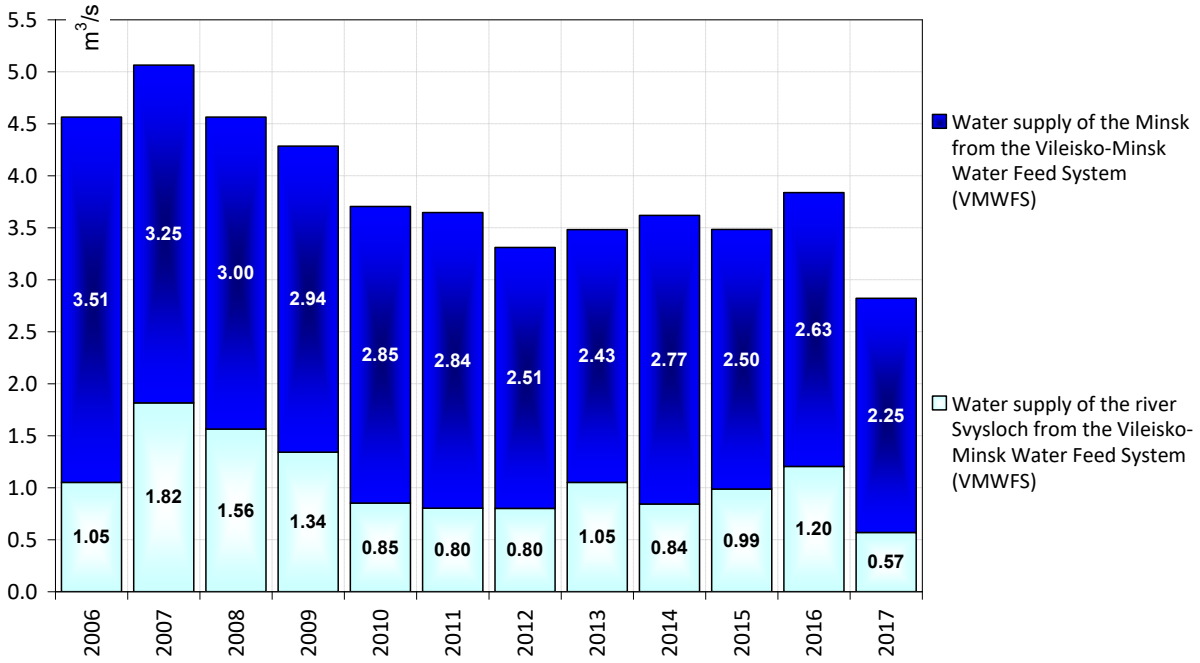


Figure 5.1 – Dynamics of total water drainage in the Vileyka-Minsk water system

[7] –information on the General Plan of Minsk, electronic source
http://www.minskgrado.by/documents/%D0%B3%D0%B5%D0%BD%D0%BF%D0%BB%D0%B0%D0%BD.pdf

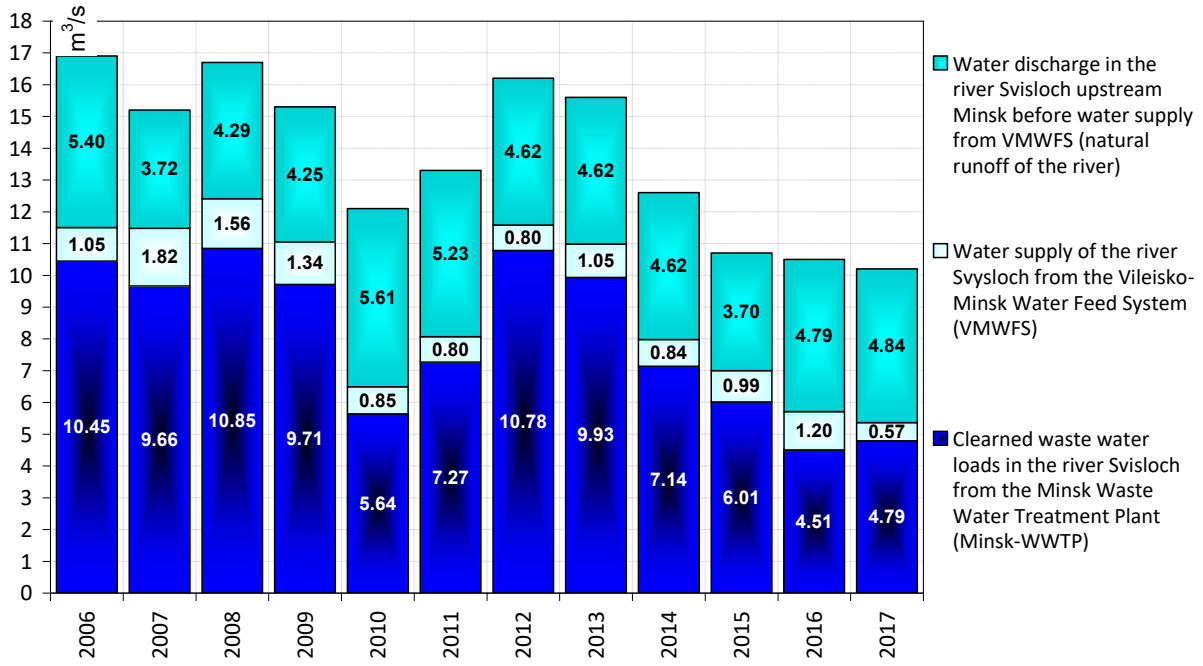


Figure 5.2 – Dynamics of changes in the flow of the river Svisloch taking into account its own flow (above Minsk), water inflow from WMWS and discharge of treated wastewater of the MWWTP

For the period up to 2024, problems with water shortages for consumers (house and communal utilities, industry, agriculture and other facilities) or the threat of quantitative depletion of surface water resources are not expected.

The range of possible impacts on water resources will depend on the water use schemes and the social and economic development of society.

The following estimated indicators for water use can be defined until 2024:

– reduction of fresh groundwater extraction by 4%;

– provision of the population in the settlements with more than 10 thousand people with 100% centralized water disposal;

– provision of the population of all regional and district centers, cities of regional subordination and urban-type settlements with 100% high-quality drinking water;

– provision of the urban population with centralized water supply with a standard quality of water for 100% and the provision of the rural population up to 80%;

– provision of the rural population in agro-towns with 100%;centralized water supply with a high-quality drinking water;

– improving the quality of wastewater treatment and the reliability of the drainage system;

– an increase in the volume of replacement of water and sewer water lines and networks;

– an increase in water recycling and re-systematic up to 97%;

– improving the reliability of water supply and wastewater systems and reducing water losses during its supply and distribution up to 12%;

– ensuring the effective operation of existing treatment facilities;

– construction and reconstruction of local treatment facilities of industrial organizations;

– ensuring the purification of rain and melt waters in populated areas with a population of over 50 thousand people, as well as in resort and industrial zones;

– reduction (up to 45%) of the operation of filtration fields with their subsequent reculti-vation, construction of local treatment facilities;

– reduction of pollutants discharged into water bodies by 50%, including nitrogen and phosphorus - by 30%;

– interruption of wastewater discharge into water bodies without treatment;

– complete interruption of discharge of wastewater into lakes and reservoirs;

– the creation of new recreation areas for water bodies not involved in recreational activities.

Thus, the implementation of environmental policies in these areas will reduce the negative impact of economic activity on the environment and human health.

The state program “Comfortable housing and a favorable environment” for 2016–2020 (as amended by the editorial directives of the Council of Ministers of January 12, 2017 No.22, of August 25, 2017 No.650) includes subprogram 5 “Clean water”. The priority task of this subprogram is to improve the quality of drinking water supply and its target indicator is provision of consumers with drinking water supply. This task is planned to be accomplished through the construction of about 500 water deferrization stations, a phased transition of Minsk to water supply from underground sources. As a result of the implementation of subprogramme 5, by the end of 2020, the provision of consumers with drinking water quality should be 100 percent.

The concept of improvement and development of the housing and utilities sector until 2025 (Resolution of the Council of Ministers of the Republic of Belarus was approved on December 12, 2017 No.1037) also foresees solving the tasks of providing the population with high-quality drinking water and ensuring the treatment of wastewater discharged into water bodies in accordance with the requirements of regulation acts.

By now, an assessment of the economic feasibility of building a cascade of hydroelectric power plants on major rivers of the republic has been made. In accordance with the State program of construction in 2011–2015 of hydroelectric power stations in the Republic of Belarus “... a further increase in the production of hydroelectric power will be carried out in 2016–2019 with the phased implementation of large hydroelectric power stations on the Dnieper and Western Dvina rivers ...”.

In 2016, the experts of RUE “CRICUWR” in the framework of the international project EPIRB carried out a preliminary assessment of the impact of the planned placement of the HPP cascade on the hydrological regime of the Dnieper River, including the following seven hydropower plants: Orsha; Shklov; Mogilev; Bykhov; Vilakhovka; Zhlobin; Rechytsa.

Based on the results of a preliminary assessment of the impact on of the Dnieper River hydrological regime, the location of the HPP cascade, taking into account the definition of flood zones, as well as the general characteristics of land use, water use and biological diversity at the maximum suggested normal waterlevels (NWL), the following conclusions were made:

– on the necessity to conduct a full-scale environmental impact assessment (EIA) when developing projects for these hydropower plants, including clarifying facilities and characteristics of biodiversity falling into the flooded areas of a hydroelectric reservoir and assessing the economic feasibility of locating a hydropower plant;

– on inexpediency of locating hydropower plants in the middle and lower reaches of the Dnieper River, including the Bykhov, Viliakhovka, Zhlobin and Rechytsa hydropower stations with the maximum proposed NWL, as well as suggestions for not locating the mentioned hydropower stations in the absence of economic efficiency due to a decrease in HPP capacity while decreasing the NWL;

– on filling the reservoir of hydroelectric power plants, preferably, during the high-water period of spring flood, or in another period, but with preservation in the Dnieper River of ecological runoff [8] in the downstream, planned to accommodate hydroelectric power plants.

[8] values of the ecological flow for the main sections of the Dnieper River are presented in the Manual in the field of environmental protection and environmental management "Procedure for calculating the limiting hydrological and hydraulic characteristics of surface water bodies", developed by RUE "CRICUWR", enacted by the Order of the State Enterprise "EcologyInvest" of August 25, 2017 No. 40

5.7.2 Surface water bodies which are at risk of not achieving good ecological state (status)

Based on the analysis of hydrochemical, hydrobiological indicators, the degree of hydromorphological changes, as well as the assessment of the ecological status, 22 water bodies do not satisfy, at least, good ecological status. According to the results of the analysis, 12 water bodies were identified under the possible risk of not achieving a good ecological status. This is 11.1% of the total number of identified water bodies. There are no reasonable grounds for classifying the remaining 10 water bodies as objects under the possible risk of not achieving good environmental status due to limited information. To clarify their status in the future it is advisable to carry out their monitoring.

The following surface water bodies are referred to water bodies that are under possible risk: the Svisloch below the Minsk wastewater treatment plant, a section of the Berezina (below Borisov), and the Plissa, Udoga, Zhadunka, Uza, Gaina, Adrov, Dobysna rivers.

It was advisable to carry out additional studies to determine the level of risk of 8 identified water bodies. This includes sections of the Ola, Khoroput, Olsa, Usyazha, Rova, Lipa rivers. The results of the field research showed that all investigated water bodies are not at risk of not achieving a good ecological status.

In order to clarify the influence quantity of point sources on water bodies during the project implementation of the EPIRB, an assessment of the wastewater impact on areas of water bodies at risk was carried out according to the methodology described in the Guidance Document on Impact Analysis (Risk Assessment) on water objects[9].

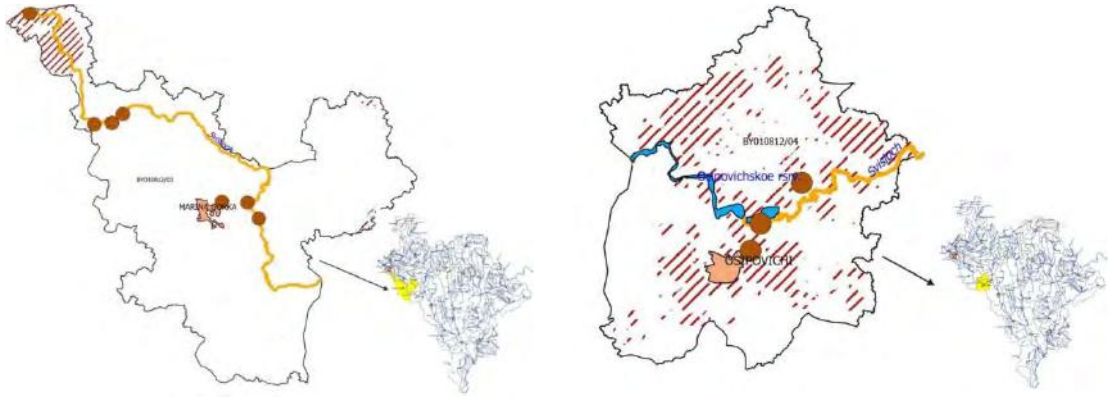
A complex analysis of groups (organic and biogenic indicators) using this Guidance Document allowed identifying water bodies that are at risk of not achieving good ecological state due to the impact of point and diffuse sources of pollution.

Among 12 water bodies that are at risk, 6 water bodies are at risk in the result of impact of point sources of pollution. This includes the Berezina River (sections BY0108/04 - below Borisov, BY0108/05 - below the confluence of the Svisloch River), the Plissa River (sections BY010805/01 - below the Sloboda settlement, BY010805/02 - below the Yalovitsa settlement), the Svisloch River (sections BY010812/03 and BY010812/04 - below the Minsk wastewater treatment plant to the mouth of the river), the Uza River (section BY011015, the Beryozovka settlement (Buda-Koshelev District) - the Bobovichi settlement (Gomel District).

Based on the criteria proposed in the Guidance document [7] for assessing the risk of the impact of diffuse sources of pollution, including crop production and livestock breeding, all 12 water bodies are at possible risk for the degree of agricultural development of the following territories: the Adrov (BY0103); the Dobysna (BY0107); the Berezina (BY0108/04, BY0108/05); the Gaina (BY010803/01); the Plissa (BY010805/01, BY010805/02); the Svisloch (BY010812/03, BY010812/04); the Udoga (BY011006); the Zhadynka (BY01101301/02); the Uza (BY011015). Among these objects, only 2 of them are at risk because of the livestock. They are the Plissa river (BY010805/01); the Uza river (BY011015).

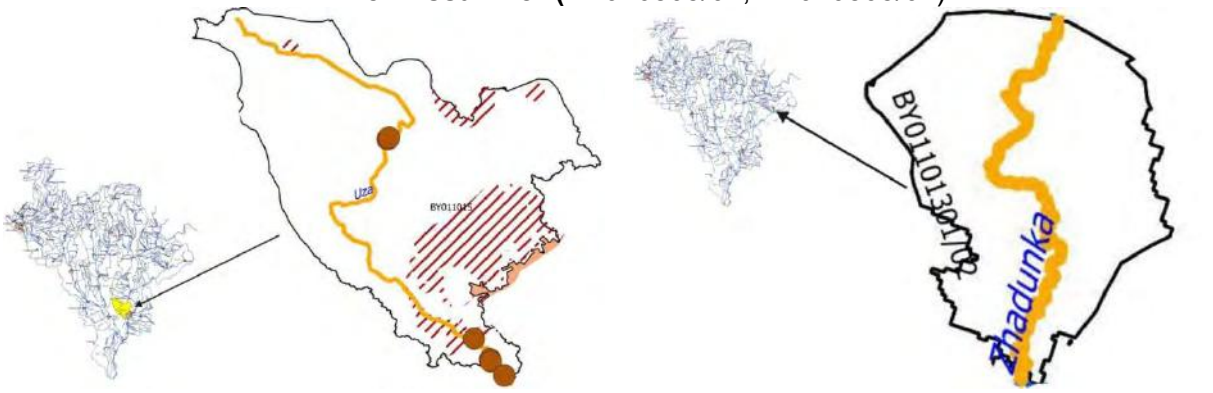
Schemes of surface water bodies at risk of not achieving good ecological status are shown in Figures 3.15, 3.16.

[9] Birgit Vogel. Guidance Document on Pressure/Impact Analysis (Risk Assessment) in the EPIRB Project Pilot Basins - RBMsolutions (Birgit Vogel) - may, 2014 - 32 p.



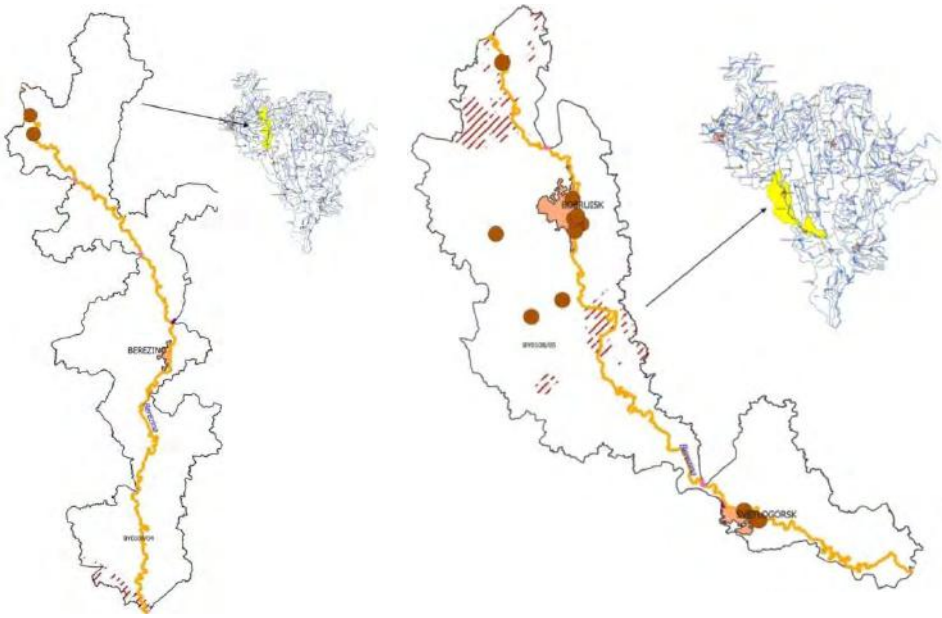
The Svisloch river (BY010812/03 , BY010812/04)

The Plissa river (BY010805/01, BY010805/02)

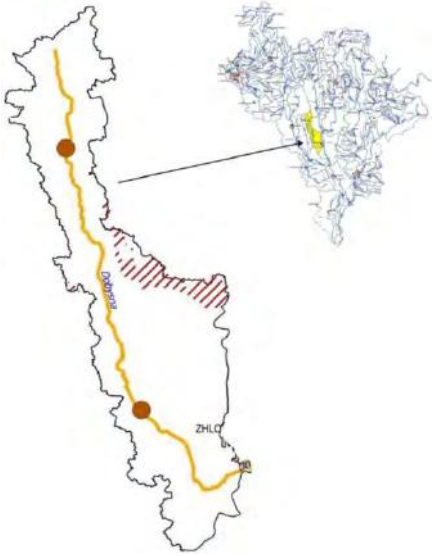


The Uza river (BY011015) **The Zhadynka river** (BY01101301/02)

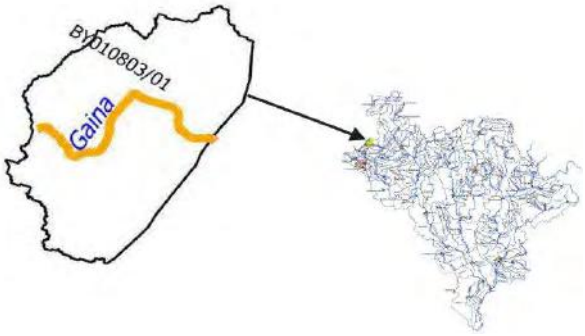
Figure 3.15 – The schemes of surface water bodies at risk



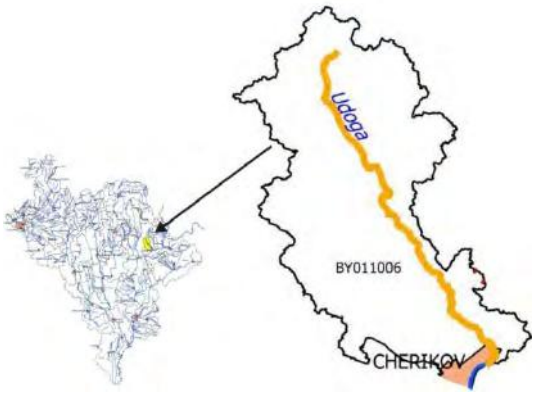
The Berezina river (BY0108/04, BY0108/05)



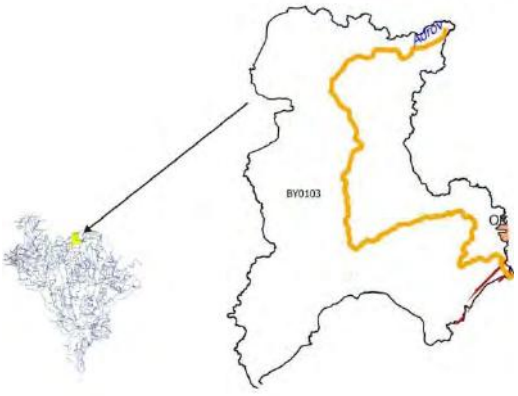
The Dobysna river (BY0107)



The Gaina river (BY010803/01)



The Udoga river (BY011006)



The Adrov river (BY0103)

Figure 3.16 – The schemes of surface water bodies at risk

Surface water bodies that are at possible risk of contamination from diffuse sources of pollution are also identified using the new methodology for assessing contamination from diffuse sources of pollution proposed in the framework of the EUWI + project (see Section 3.3 above). Using this methodology and data for 2017, 15 water bodies were identified under the possible risk of contamination from dispersed sources of pollution in the Dnieper basin. This risk is primarily due to the concentration of livestock facilities and intensive farming. The list of bodies basically coincided with the list determined by the method [7] with some differences and the addition of water bodies – the rivers Usyazha, Rudeya, Teryukha, Vyacha, Dobrich, Lakhva, Volma. The lists of these bodies are given in Table 3.4. The bodies are also shown in Table 13.4 of Appendix A.

Table 3.4 – Water bodies under the possible risk of dispersed (diffuse) sources of pollution due to agricultural pollution of nitrogen and phosphorus (as part of P_2O_5).

Water body name	Water body code	Specific nitrogen load, N kg/ha	Specific phosphorus load (as a part of P_2O_5)
THE PLISSA	BY010805/01	28.979	20.374
THE USYAZHA	BY01080302/02	22.673	15.856
THE VOLMA	BY01081202/02	20.969	18.004
THE PLISSA	BY010805/02	19.964	13.431
THE ROVA	BY010806/01	18.706	-
THE RUDEYA	BY0110080301/01	17.117	16.277
THE TERYUKHA	BY011017	15.790	-
THE SVISLOCH	BY010812/02	17.208	17.208
THE VYACHA	BY01081201/03	17.208	17.208
THE SVISLOCH	BY010812/01	16.766	16.766
THE DOBRICH	BY011009	15.539	15.539
THE LAKHVA	BY0104	15.489	14.648
THE VOLMA	BY01081202/01	15.357	14.544
THE DNIEPER	BY01/03	14.834	-
THE UZA	BY011015	14.486	-

It should be noted that among 12 surface water bodies that are at risk of not achieving “good” status, 4 water bodies may not achieve “good” status by 2024 and even by 2030. These water bodies include the following watercourses areas:

- the Svisloch River below Minsk to the dam of the Osipovichsky reservoir - due to population growth, a great number of point sources within the growing Minsk agglomeration, including industry and sewage treatment at the Minsk wastewater treatment plant, and low self-purifying capacity of the river ;
- the Svisloch River below the Osipovichsky reservoir – due to secondary pollution of the river below the reservoir dam due to the maceration of heavily polluted suspended bottom sediments in the reservoir and their inflow into the downstream;
- the Uza River – due to a great number of point sources and the possibilities of wastewater treatment within the growing Gomel urban agglomeration;

– the Plissa River – due to a great number of point sources of pollution due to a significant increase in anthropogenic load associated with the location of the satellite city Minsk in Smolevichi district, as well as a low self-purifying capacity of the river.

General map of water bodies risk assessment is given in Appendix B (figure 26).

5.7.3 Groundwater at risk[10]

One underground water body in the Dnieper basin was identified as a water body at risk of not achieving good status in terms of chemical and quantitative indicators. This body is located on the territory of Minsk and its suburbs and includes groundwater bodies in the Dnieper-Sozh and Proterozoic sediments in the area of the Minsk city agglomeration on the sites of placement of 12 group communal water intakes of Minsk and single wells and group water intakes of economic objects in the city Minsk and Minsk region. Unregulated groundwater extraction from departmental water intakes around Minsk exceeds their available resources. For this reason, the Dnieper-Sozh and Proterozoic groundwater bodies near Minsk are rated as those under the risk of not achieving a good quantitative and chemical status.

Twelve water intakes provide domestic and industrial water supply of the city of Minsk with a population of over 2 million. Each water intake consists of dozens of production wells with a depth of 50–200 m. The oldest water intakes (Novinki, Petrovschina, Zelenovka and Drazhnia) were built in the years 1930–1950 and are located within the city territory. Other water intakes (Borovlyany, Ostrovy, Volma, Vikovshchina, Vodopoy, Fe-litsianovo and Zeleni Bor) are located 8–25 km away from the city in a more favorable environment. The water intake "Novinki" is located in the north-western part of Minsk. It was built in 1932. The extraction of groundwater at that time was carried out only from the Dnieper-Sozh fluvio-glacial complex. In 1958, the operation of ground-water and Valdai aquifer terrigenous complex began.

Based on information of the Minskvodokanal[11] the amount of water extracted from the exploited aqui-fers by the intake wells of the Minskodokanal over the past 7 years did not exceed 375 thousand m^3/day, which is about 46% of those operational freshwater reserves equaling to 821.5 thousand m^3/day, which are approved by the Ministry of Natural Resources of July 10, 2013 No.2210-OD and from 05.02.2016 No.29-OD.

The long-term intensive extraction of groundwater from the intermoral Dnieper-Sozh aquifer complex for the water supply of the city of Minsk created an extensive depression crater 40 km in diameter and caused a decrease in the groundwater level by 25–30 m in the central part of the funnel (Figure 3.17).

[10] the section was prepared using the results of the EPIRB project

[11] the message of UE Minsk-Vodokanal" of 10.22.2018 No.1-26/1778 to the Minsk City Committee for Natural Resources and Environmental Protection

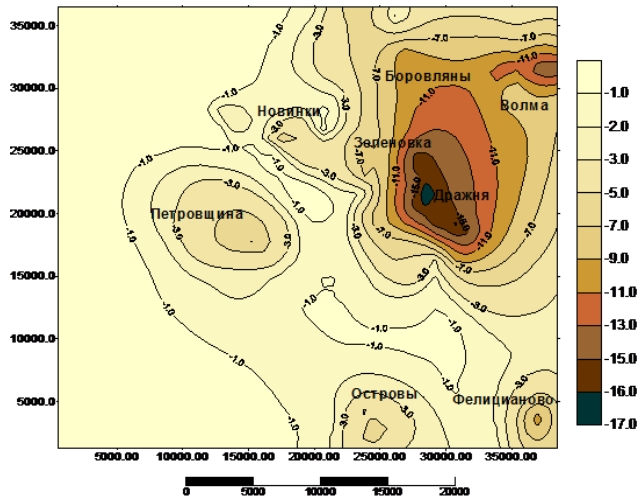


Figure 3.17 – Depression funnel in the Dnieper-Sozh water-bearing complex around Minsk in 2008. *On the right is the scale of water level lowering, on the left and below is the scale of the map in meters*

The second most important aquifer used for groundwater extraction in Minsk is the Upper Proterozoic (Valdai) aquifer. It provides 8–10% of all groundwater supplied to the city. The aquifer is located at a depth of 160–320 m, and it is well protected from surface contamination. Based on the information of the UE Minskvodokanal [9], the water extraction from the Valdai aquifer does not exceed 15 thousand m^3/day. (Approved operating reserves equal 62.2 thousand m^3/day.) Also, according to the UE Minskvodokanal, on the basis of many years of observation of the operation of the underground water intake of the UE Minskvodokanal, there is a tendency of decreasing in the amount of water abstracted. However, intensive exploitation of this aquifer led to the formation of a large depression crater with a diameter of 40–70 km and a decrease in water level of 20–25 m in the center of the funnel (Figure 3.18).

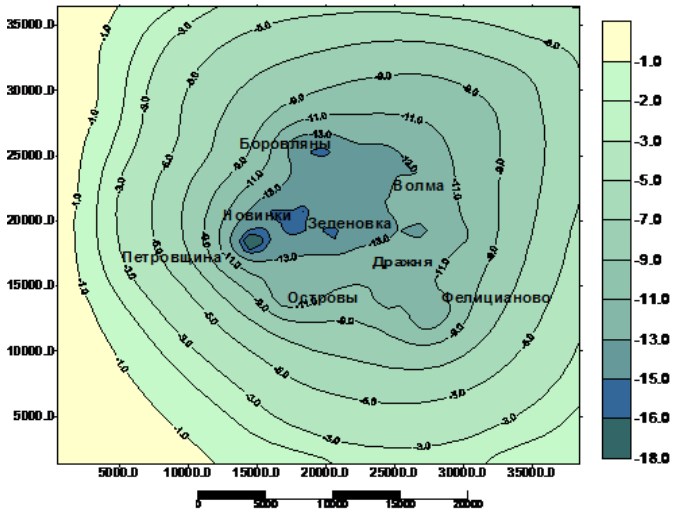


Figure 3.18 – Depression funnel in the Upper Proterozoic aquiferous complex around Minsk in 2008. *On the right is the scale of the water level lowering, on the left and below is the scale of the map in meters*

Heavy extraction of groundwater also led to a decrease of the water level in the uppermost unconfined (groundwater) aquifer (Figure 3.19), which is closely associated with river valleys: the aquifer enriches rivers during dry (low-flow) periods.

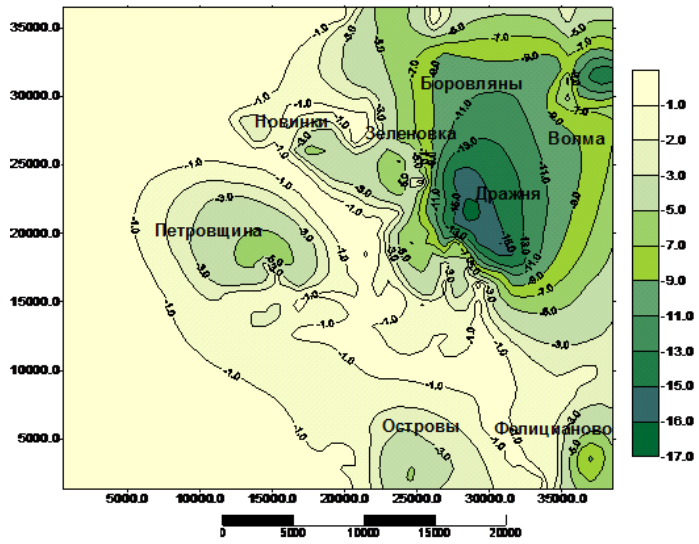


Figure 3.19 – Depression funnel in the groundwater aquifer around Minsk in 2008. *On the right is the scale of the water level lowering, on the left and below is the scale of the map in meters*

The exploitation of groundwater not only causes a large-scale decreasing of the water level, but also reduces the flow of small rivers around Minsk. In low-flow periods, these rivers feed depleted aquifers and lose their own current. This phenomenon was first noted in the Minsk region in 1974, when 7 km of the Volma river disappeared in the summer, 4 years after the establishment of the Volma water intake, which pumps groundwater from the Dnieper-Sozh aquiferous complex.

At present, the upper streams of the Tsna, Loshitsa, Slepyanka, Volma, Trostyanka and Sennitsa rivers are under the negative influence of the Minsk water intakes.

Extraction of groundwater also increases the pollution of productive aquifers. The water intake in Novinki is one of the oldest in Minsk; it has been used for water supply since 1932. Groundwater monitoring has revealed the development of anthropogenic pollution of aquifers, mainly by nitrates. In 1932, there were no nitrates in the groundwater of this water intake, but by 1970 the concentration of nitrate in a number of wells reached 20–27 mg/l. And in 1990 it was 50–65 mg/l (European standard for drinking groundwater is 50 mg/l). Analysis of groundwater samples taken from the water intake in 2009 showed that nitrate concentrations reached 62.3–81.8 mg/l in 9 wells. In 18 wells the concentration of nitrates did not exceed the standard for drinking water, but it was higher than the natural background values. Due to the reduction of anthropogenic pressure associated with the shutdown of the poultry farm named after Krupskaya, according to the information of the UE Minskvodokanal, since 2012 there has been a negative trend in the nitrates content in the water taken from the water supply wells of the “Novinki” water intake.

In order to study in detail the sources and causes of groundwater pollution at the “Novinki” water intake as part of the international project “Environmental Protection in International River Basins”, a pilot project “Detailed assessment of the groundwater pollution in the area of the “Novinki” water intake in Minsk Republic of Belarus" was accomplished.

To achieve this goal, the following tasks were completed as part of a pilot project: the collection, generalization and study of available geological and hydrogeological information on the “Novinki” water intake was carried out; the degree of protection of groundwater in the study area was assessed; the sources of groundwater pollution are studied in detail and a schematic map of the location of the identified pollution sources has been compiled using GIS technology; the mathematical modeling of geofiltration and geomigration of groundwater in the area of the “Novinki” water intake was performed using the GMS program.

On the basis of the accomplished studies, as well as the results of mathematical modeling, a list of

measures aimed at improving the quality of groundwater produced at the “Novinki” water intake facility (tables 21.1, 21.2 of Appendix A) was proposed.

6 INFORMATION ON PROTECTED AREAS

6.1 Protective sanitary zones of drinking water supply sources

Protective sanitary areas (PAs) of water supply sources and domestic water supply pipelines in the Dnieper basin as well as in Belarus are established in accordance with the Law of the Republic of Belarus “On drinking water supply” and sanitary rules and norms SanPiN of 30 December 2016, No.142 “Sanitary norms and rules “Requirements for the organization of protective sanitary areas of water sources and centralized drinking water supply systems”. The PAs are organized as part of the three areas: the first area (of a strict regime) includes the territory of the location of the water intakes, the sites of the location of all the water-retaining constructions and the water-conducting channel.

The second and third areas (areas of restrictions) include the territory intended to prevent water pollution of water supply sources. Sanitary protection of water conducts is provided by a sanitary-protective strip. In each of the three areas, as well as within the sanitary protection zone, according to their purpose, a special regime is established and a set of measures aimed at preventing the deterioration of water quality is determined.

The boundary of the first area is set at a distance of at least 30 m from the water intake when using protected groundwater. And the boundary is set at a distance of not less than 50 m while using insufficiently protected groundwater.

The boundary of the second area of the sanitary protection zone is determined by hydrodynamic calculations, with regard to the fact that the microbial contamination entering the aquifer beyond the second area does not reach the water intake. The boundary of the third area of the sanitary protection zone aimed to protect the aquifer from chemical contamination, is also determined by hydrodynamic calculations.

The specific location of the sources of drinking water supply and their sanitary protection zones is information of limited access without the need for a detailed presentation in this RBMP.

Basic data on the operation of groundwater for the group water intakes of the Dnieper basin is given in table 14.2 of Appendix A.

6.2 Economically significant species (fish, shells)

Economically important fish species in the Dnieper basin are produced at specialized fisheries enterprises, the most important of which are the Rybhoz Volma OJSC (Cherven disctrict), the CUE "Trout farm Lohva" (Kostyukovichi district), the JSC "Rybhoz Svisloch" (Osipovichi district). The list of surface water bodies leased for fish-breeding (according to data for 2017) is given in table 16 of the Annex including artificial ponds.

There are no special protected areas within the water bodies sites associated with permanent restrictions on fishing because of the presence in these water bodies of economically significant fish species and (or) unique mollusks.

6.3 Bathing waters

Information on surface water bodies used for recreation, sports and tourism in the Dnieper Basin, in places identified by local executive and administrative bodies for 2017 are shown in Annex.

6.4 Water protection zones and vulnerable areas of water bodies

In accordance with the Water Code of the Republic of Belarus, water protection zones are established to prevent pollution, clogging and depletion of water bodies, as well as preserve the habitat of wildlife fauna and the growth of plants in areas adjacent to water bodies. Within the water protection zones, coastal zones of strict protection regime are distinguished. A special regime of economic and other activities is established in the water protection zone of rivers and reservoirs.

The projects on water protection zones and coastal area of water bodies in the Dnieper basin were designed by the RUE “CRICUWR” on maps of 1:50000 scale for administrative districts. The setting of water protection zones is one of the most effective organizational and preventive measures for the ecological optimization of landscapes of valley complexes and it allows:

– to improve hydrochemical and hydrological regimes of surface waters;

– to improve the qualitative composition of groundwater drained by the river network;

– to reduce water and wind erosion: abrasion of the coastal zone;

– to save coastal meadow and tree and shrubbery vegetation;

– to preserve breeding grounds for fish and habitats of land animals.

Projects of water protection zones and coastal areas of small rivers, streams and reservoirs were developed by the Belgiprozem Institute and its regional branches in 1988–1991 on maps M 1: 10000 and approved by decrees of regional executive committees in 1990-1991.

At present, it is necessary to clarify the boundaries of water protection zones and coastal areas of small rivers, taking into account modern understandings of their role in the use and preservation of water resources.

The boundaries of water protection zones and coastal areas of the Svisloch, Berezina and Ptich rivers within the Minsk region were established in the result of an integrated assessment of the natural conditions (relief structural features, soil cover, geological and hydrogeological conditions, the distribution of greenery) and the nature of land use. When determining the boundaries of water protection zones and coastal areas, data on modeling of slope erosion processes as a result of the impact of surface runoff were also taken into account.

The width of the water protection zone of the Berezina river was 700–6000 m, the Svisloch – river 700–2100 m and the Ptich river – 700–4900 m. The boundaries of the coastal areas of the studied rivers are defined taking into account clause 11 of the Regulation on water protection zones and coastal areas of large and medium rivers, according to which the coastal area is defined to 200 meters in size. If there were floodplain

lakes and oxbows lakes adjacent to rivers, the generalized width of the coastal area was defined. The width of the coastal area of the Berezina river was 125–500 m, the Svisloch – 125–180 m and the Ptich – 125–150 m.

The area of water protection zones of the Berezina, Svisloch, Ptich rivers within the Minsk region is 96187.55 hectares, which corresponds to 2.4% of the territory of the region. It was revealed that within this territory there are 73 agricultural organizations and farms, 10 forestry enterprises, 152 settlements belonging to 35 village councils. In addition to the main categories of land users, the boundaries of the water protection zone include the lands of 4 industrial enterprises, 45 garden companies, 3 health institutions, 47 other land users represented by small enterprises, offices, and road-construction organizations.

Agricultural reclamation of the territory of water protection zones is 30%. Plowing up is about 11.4%, which is significantly lower than the average for the region (47% and 31.5% respectively).

The forest total area within the water protection zones is 41701.3 hectares or 43% of the area of the water protection zone, represented by forests of the first group. Tree and shrubbery vegetation occupies 6805.04 hectares or 7.1% of the area of the water protection zone.

There are 12449.05 hectares of land within the boundaries of the coastal areas of the Berezina, Svisloch, and Ptich rivers, which is about 12.9% of the water protection zone.

The agricultural reclamation of the coastal area is 40.3%. These are mainly floodplain meadows used for hay-fields. The occupation density is 20% and shrubbery density is about 11%.

The assessment of the ecological state of the territory of the water protection zones of the Minsk region showed that, according to the conditions of its functional use, this territory belongs to the territories with a satisfactory level of anthropogenic load, as there are livestock complexes and farms, mechanical workshops, household yards, etc. within the water protection zones.

Within the Gomel region, the width of the water protection zone of the Dnieper river was 200–10000 m. The water protection zone of the Drut river is 200–3200 m and the water protection zone of the Berezina river is 200–6500 m.

The width of the coastal area of the Dnieper river was 20–600 m, the coastal area of the Drut river is 25–500 m and the coastal area of the Berezina is 20–1100 m.

The area of water protection zones of the Dnieper, Drut and Berezina rivers within the Gomel region is 191030.29 hectares, which corresponds to 4.7% of the region territory. It was revealed that within this territory there are 138 agricultural organizations and farms, 9 forestry enterprises, 163 settlements belonging to 52 village councils. In addition to the main categories of land users, the boundaries of the water protection zone include 5 industrial enterprises, 95 garden companies, 6 health institutions, 83 other land users represented by small enterprises, offices, and road-construction organizations.

Agricultural reclamation of the territory of water protection zones is 34%, plowing up is about 9%, which is significantly lower than the average for the region (41% and 23% respectively).

The total forest area within the water protection zones is 62804 hectares or 33% of the area of the water protection zone, is represented by forests of the first group. Tree and shrubbery vegetation occupies 15968 hectares or 8% of the area of the water protection zone.

There are 22536.37 hectares of land within the borders of the coastal areas of the Dnieper, Drut and Berezina rivers, which is about 12% of the water protection zone.

The agricultural reclamation of the coastal area is 38%. These are mainly floodplain meadows used for hay-fields. The occupation density is 13%, and shrubbery density is about 23%.

The assessment of the ecological state of the territory of the water protection zones in the Gomel region showed that, according to the conditions of its functional use, this territory belongs to areas with a satisfactory level of anthropogenic load, as there are livestock complexes and farms, mechanical workshops, household yards, etc. within the water protection zones.

Within the Mogilev region, the width of the water protection zone of the Dnieper river was 200–5000 m. The width of the Sozh water protection zone is 200–6000 m. The width of the coastal areas of the Dnieper River is 20–500 m, and the width of the coastal area of the Sozh river is 10–500 m.

The area of the water protection zones of the Dnieper and Sozh rivers within the Mogilev region is 86953.12 hectares, (including the Dnieper river with the area of 47733.79 ha, the Sozh river with the area of 39219.33 ha), which corresponds to 3% of the territory of the region.

The main categories of land users in the water protection zone of the Dnieper river are agricultural organizations and farms (59.8% of the water protection zone), settlements (8.7%), forestry enterprises (26.6%). Within districts the distribution of land is as follows: Shklov district – 46.2; 12.5; 34; Mogilev district – 51.6; 10.1; 30.4; Bykhov district – 69.5; 6.5; 21.8.

The main categories of land users in the water protection zone of the Sozh river are agricultural organizations and farms (48.1%), settlements (4.2%), forestry enterprises (37.8%). Within districts the distribution of land is as follows: Mstislavl district – 81.1; 11.5; 5.4; Krichev district – 65; 6.1; 23.9; Klimovichi district – 64.7; 4.5; 30.1; Cherikov district – 27.9; 2.4; 64.8; Slavgorod district – 36.6; 1.6; 36.7.

Industrial enterprises are represented by a woodworking integrated plant in the Cherikov district (35.8 hectares) and the Krichev beverage factory (6.01 hectares). Within the territory of water protection zones of the Dnieper and Sozh rivers there are 90 settlements.

There are 10653.44 hectares of land within the boundaries of the coastal area of the Dnieper and Sozh rivers, which is about 12.25% of the water protection zone.

The agricultural reclamation of the coastal area is 67.8%. These are mainly floodplain meadows used for hay-fields. The occupation density is 10.5%, and shrubbery density is about 6.5%.

The assessment of the ecological state of the territory of the water protection zones of the Mogilev region showed that, according to the conditions of its functional use, this territory belongs to the territories with a satisfactory level of anthropogenic load, as there are livestock complexes and farms, mechanical workshops, household yards, etc. within the water protection zones.

The information on objects that have a harmful effect on water quality, which are located in water protection zones and coastal areas of water bodies in the Dnieper basin, is given in Table 20 of Appendix A.

According to the data on local monitoring of pollution sources of surface waters and receiving water bodies, the occurrence of objects in water protection zones and coastal zones that have a harmful effect on water quality, and based on the analysis of diffuse sources of pollution, the following water bodies are the most vulnerable areas of in the Dnieper basin: the Dnieper below Orsha, Shklov, Mogilev, Bykhov, Zhlobin, Rechytsa cities; the Berezina below Borisov, Bobruisk cities, the inflow of the river Svisloch; the Plissa below Zhodino; the Svisloch below the discharge of the Minsk wastewater treatment plant (MWTP); the Uza; Milchansk ditch; Gaina; Rova; Dobysna; Zadunka; Adrov.

Table 18 of Appendix A provides information on water protection zones and coastal areas for identified surface water bodies.

6.5 Characteristics of specially protected natural areas for the preservation of specially protected species of flora and fauna

The network of specially protected areas (SPAs) of the Dnieper river basin consists of 2 reserves, 18 natural areas of national significance (Table 1.1), as well as natural areas of local significance, nature monuments, etc.

Due to the special nature protection status, the SPAs contain the majority of the ecosystems that have been preserved in the natural state, the distribution and the area of which in the Dnieper river basin as a result of diverse economic activities in the last 50 years has dramatically decreased.

Table 1.1 – List of **specially protected natural areas** of national importance **within** the Dnieper basin

№	Title	Type	IUCN Type (International Union for Conservation of Nature and Natural Resources)
1	Berezinskiy	biosphere reserve	Ib
2	Buda-Koshelevskiy	biosphere reserve	IV
3	Volmyanskiy	biosphere reserve	IV
4	Vydritsa	landscape reserve	IV
5	Glebovka	biological reserve	IV
6	Denisovichskiy	biological reserve	IV
7	Dnieper-Sozhskiy	biological reserve	IV
8	Zaozerye	hydrological reserve	IV
9	Kopysh	biological reserve	IV
10	Duleby Islands	hydrological reserve	IV
11	Pekalinskiy	biological reserve	IV
12	Polesskiy	radiation ecological reserve	II
13	Prilepskiy	landscape reserve	IV
14	Smychok	landscape reserve	IV
15	Stiklevo	biological reserve	IV
16	Chernevichskiy	landscape reserve	IV
17	Chernevskiy	biological reserve	IV
18	Chirkovichskiy	biological reserve	IV
19	Yukhnovskiy	biological reserve	IV

Changes in the state of natural landscapes and biological diversity were due to the direct destruction of natural ecosystems (rivers, bogs, floodplains, alluvial forests, etc.), including a large-scale drainage reclamation of wetlands conducted here. This reclamation activity led to a reduction of the bog areas, lowering of the groundwater level, straightening of river beds, the disappearance or reduction of a number of the most valuable and standard associations of oak, aspen, lime, black alder and elm forests, as well as floristic and

faunal complexes. It is established that over the last 100 years 25 species of higher vascular plants have disappeared and about 40 species of animals have lost their habitats.

According to the data obtained as a result of the inventory of wetlands in Belarus, more than 17% of the basin area was drained as a result of reclamation works in the Dnieper Basin. As a result of reclamation of lowland bogs, 11 species of bog plants disappeared in territory of Belarus, and the occurrence of 115 species has decreased dramatically. Biodiversity of the territory is characterized by the presence of more than 90 species of fish (60 of which live in the Dnieper), and about 182 species of birds and more than 2500 plant species. In the Dnieper basin there are 4 rare species of fish that are endangered and listed in the Red Book of the Republic of Belarus. They are sterlet and brook trout, vimba, barbel. Sterlet occurs within no more than 10 isolated places, such as the Dnieper River (Bykhov and Rogachev districts) and some of its tributaries (the Besed, the Sozh, the Berezina, and the Svisloch). Trout is currently not found in the Svisloch, Vyacha rivers and other watercourses, where it used to live earlier.

The list of the most significant ecosystems of the Dnieper basin includes Berezinskiy Biosphere Reserve; lake-forestry complex "Golubitskaya Pushcha"; forestry complex "Puhovichsky bogs"; floodplain complex "Dnieprovsko-Sozhskiy" (reserve of national importance); floodplain of the Dnieper River (Zhlobin-Rechitsa); floodplain of the Sozh River (Vetka-Chechersk area); natural complexes "Verhoviya Dniepra", "Besedskiy" ("Klimovich-Kostyukovichskiy") and "Svisloch-Berezinskiy"; forest complex “Dobrushskiy”.

The largest area is occupied by the Berezinskiy Biosphere Reserve. The Polesskiy Radiation Ecological Reserve was created after the Chernobyl NPP accident and is located within the larger area in the Pripyat river basin and, to a lesser extent, in the Dnieper river basin. In addition, within the territory of the basin there is a large number of landscape reserves (Vydritsa, Chernevichsky, etc.), hydrological reserves (Zaozerye, Duleba, Svisloch-Berezinsky, etc.), biological reserves (Dnieper-Sozhskiy, Kopysh, Mateevichskiy and others). Here there are unique areas of forests and plantations of valuable tree species (Chigirin planting of valuable tree species, Dobrush spruce forests, Veprin oak forest, etc.).

The landscape map-scheme of the Dnieper basin with marked specially protected areas is presented in Appendix B (figure 2).

7 SURFACE WATER AND GROUNDWATER MONITORING, INCLUDING THE SCHEME OF LOCATION OF OBSERVATIONS POINTS OF THE GOVERNMENTAL MONITORING NETWORK OF SURFACE AND GROUNDWATER STATE AND SUGGESTIONS FOR ITS OPTIMIZATION

7.1 Monitoring

7.1.1 Surface waters

The list of existing observation points of the State Network for Observation of Surface Water on hydrochemical and hydrobiological indicators, including transboundary ones, was approved by order of the Ministry of Natural Resources and Environmental Protection of the Republic of Belarus of January 30, 2015 No.44-OD “On some issues of monitoring surface and groundwater at the observation points of the National Environmental Monitoring System in the Republic of Belarus”. All observation points on the surface water monitoring network are included in the state register of observation points of the NEMS in the Republic of Belarus (Resolution of the Ministry of Natural Resources and Environmental Protection of the Republic of Belarus of December 17, 2008 No.119 "Instructions on the procedure for maintaining the state register of observation points of the National System environmental monitoring in the Republic of Belarus”).

Principles of organizing a network of monitoring points for surface water according to hydrochemical and hydrobiological indicators as part of the NEMS of the Republic of Belarus, including the principles of organizing a network of observation points, the order of organizing and conducting observations, as well as a list of indicators of the state of surface water and frequency observations were approved by the order of the Ministry of Natural Resources and Environmental Protection of the Republic of Belarus of January 30, 2015 No. 44-OD “On some issues of the organization of the monitoring of surface water and groundwater within the sites of NEMS of the Republic of Belarus". This information is also given in the TCCP 17.13-04-2014 (02120) ‘Protection of the environment and natural resources. Analytical (laboratory) control and monitoring. Rules for conducting observations of surface waters on hydrochemical and hydrobiological indicators.”

Monitoring of surface waters in the Dnieper river basin on the territory of Belarus is conducted within 38 water bodies (25 rivers, 10 reservoirs and 3 lakes). The network of monitoring points includes 88 hydrochemical observation points, including 5 background and 6 transboundary sections of rivers (scheme-map No.8 of Appendix B, Tables 8–12 of Appendix A). Hydrobiological observations were conducted within 23 rivers, 10 reservoirs and 3 lakes – 36 water bodies.

Observations on the state of surface waters on hydrochemical and hydrobiological indicators at observation points of the state observation network are necessarily carried out with the list of indicators of the state of surface waters, including 30 hydrochemical indicators divided into 5 groups, and 5 hydrobiological indicators.

The frequency of observations is established depending on the anthropogenic pressure on the water body and the category of the observation point (national, background, transboundary).

Observations on hydrochemical indicators within background observation points are carried out monthly with a frequency of 1 time per 2 years.

Observations on hydrochemical parameters for reservoirs are carried out quarterly with a frequency of 1 time per 2 years:

– in winter period;

– during the end of the spring flood;

– during the summer low water period;

– in the period which precedes freezing period.

Observations on hydrobiological indicators within water bodies are carried out during the vegetation period with a frequency of 1 time per 2 years.

In addition, transboundary observation points monitor the content of persistent organic pollutants (POPs) in surface waters and bottom sediments.

Observations are carried out at least once a year (in II – III quarters) on surface waters and at least once in 3 years on bottom sediments. If the POPs in surface waters and bottom sediments are absent, the observations are carried out at least 1 time in 5 years. Herewith polychlorinated biphenyls (PCBs), organochlorine pesticides (OCPs) are determined.

The indicators of radioactive contamination (cesium-137 and strontium-90) are monitored within several transboundary observation points located on the territory affected by the accident at the Chernobyl NPP. Observations on hydromorphological indicators in the Republic of Belarus in the framework of surface waters monitoring are not yet carried out. Since 2012, within the framework of the realization of the State Program for the Operation and Development of the NEMS of the Republic of Belarus (2011–2015), scientific studies have begun on the creation of the basics of hydromorphological monitoring in the areas of large hydraulic engineering structures.

Observations on sources of pollution of surface waters are carried out within the framework of local monitoring, which is carried out by nature users. The resolution of the Ministry of Natural Resources and Environmental Protection of the Republic of Belarus No.5 of January 11, 2017 approved a list of users of natural resources conducting local monitoring.

7.1.2 Groundwater

In accordance with the objectives of groundwater monitoring, the observation network is divided into **three** ranks: *national, background* and **transboundary.**

The background monitoring network is used for studying the natural (background) regime of groundwater, which is the initial (reference) mode for assessing the anthropogenic load, taking into account the total hydrodynamic and hydrogeochemical zonality of groundwater.

At the posts of national rank, the features of the formation of groundwater due to the natural conditions of a particular region and the peculiar anthropogenic changes in the underground hydrosphere are studied.

A *transboundary* monitoring network is being formed, which includes the following points:

- the points which are close to the state border of the Republic of Belarus;

- the points with minimal anthropogenic load;

- the wells that are equipped by different aquifers (complexes) for a comprehensive assessment of transboundary transport.

85 operating wells within 5 transboundary, **17** national, 2 on the background posts are located in the Dnieper river basin.

The existing groundwater monitoring network within the study area includes 24 existing hydrogeological posts: Vysokovsky, Babinovsky, Klyukovsky, Starokoytinsky, Vasilyevsky, Sverzhensky, Iskrovsky, Proskurninsky, Antonovsky, Mikhailovsky, Khonovsky, Babichsky, Grebenevsky, Vasilevichsky, Minsky, Berezinsky I, II, Logoysky, **Derazhichsky, Kanichsky, Litvinovichsky, Novoluchevsky, Ostersky, Poddobryankovsky** (scheme-map No.9 of Appendix B, tables 14, 14.1, 14.2 of Appendix A).”

Local groundwater monitoring is carried out by users of natural resources within locations where objects of adverse impact are located: municipal and industrial waste landfills, sludge treatment facilities, agricultural irrigation fields, filtration fields, industrial sites of enterprises, storage sites for oil products, disposal of unusable pesticides, etc.

7.2 Suggestions for the optimization of the existing observation network (prospective development of the monitoring system)12

Surface waters

The existing system for surface water monitoring in the Dnieper basin only partially meets the criteria of the WFD. According to the WFD, there should be the following three types of monitoring:

1. Observational monitoring is carried out within the entire catchment area or part of it within the significant areas (large rivers, large lakes, significant streams, etc.) to obtain a general assessment of the ecological state of surface waters. Its main purpose is to ensure the correctness of the developed procedure for environmental impact assessment. If necessary, one should supplement and improve it, assess long-term trends, determine the requirements for making adjustments to the current RBMP, and obtain the necessary information to develop the next RBMP.

2. Operational/in-process (operating) monitoring is carried out according to the RBMP in order to control those water bodies for which there is a risk that the environmental objectives set forth in the WFD may not be achieved, and also to assess the impact of measures taken under the Program of Activities on the ecological state of the waters. Operational monitoring is carried out on those bodies for which, based on impact assessment or surveillance monitoring, it has been established that there is a risk of not achieving the established environmental goals, as well as for water bodies which are polluted by the discharged hazardous substances included in the Priority List.

Operational monitoring is carried out for only those elements of quality and those parameters that are sensitive to specific impacts.

3. Research monitoring is carried out in cases when:

– any excess for unknown reasons is established;

[12] the section prepared in the framework of the EPIRB project

- the results of surveillance monitoring show that target indicators cannot be achieved, and operational monitoring has not yet been put into effect;
- it is necessary to determine the scale and degree of impact of accidental pollution.

Research monitoring serves to provide the governing bodies with the necessary information to develop a program of activities to achieve environmental objectives and mitigate the consequences of accidents.

Observational monitoring of surface water

The selection of sampling sites and the development of an observational monitoring program is based on interconnected subsystems that perform the primary OM tasks outlined above. The OM subsystems for watercourses include the following conditions (sections):

- OM1: to be a sample of the general state of surface waters;
- OM2: determination of long-term trends (assessment of long-term changes in natural conditions and assessment of long-term changes under the influence of anthropogenic activity);
- OM3: addition and examination of risk assessment;
- OM4: large rivers and significant transboundary sections of rivers and lakes.

12 types of surface water bodies were identified in the Dnieper basin. However, it was possible to find sampling points corresponding to the conditions of the observational monitoring programs (OM) only for 5 types of surface water bodies.

Suggestions for optimizing the existing network of surface water observations include additional sampling sites for the observational monitoring program (OM) in the Dnieper basin, which are presented in Table 4.1 and are shown on map-scheme №12 of Appendix B. All 9 sampling points were selected in terms of representativeness for the SM program. But lakes that are subject to this type of monitoring have not been identified in the Dnieper basin.

Table 4.1 – Proposed sampling sites for observational monitoring in the Dnieper basin in Belarus

№	River name	Water body type	Expected status/ potential	Sampling point	Risk category	Subsystem of SM
1	The Volchas	SWB	RC	the entry	NR	OM1
2	The Ut	SWB	RC	Tereshkovichi	NR	OM2
3	The Greza	SWB	RC	Vyazma	NR	OM1
4	The Vabich	SWB	RC	Barsyki	NR	OM1
5	The Usha	SWB	RC	Usha	NR	OM1
6	The Drut	SWB	good	Vyazma	NR	OM1
7	The Drut	SWB	satisfactory	Krugloe	R	OM2
8	The Plavna	SWB	satisfactory	Vysokaya gora	R	OM1
9	The Dnieper	SWB	good	Dubrovno (above)	NR	OM2

Note; SWB – surface water body; RC – reference conditions; NR – no risk; R – risk.

Operational monitoring of surface waters

The selection of the sampling site for the activities within the framework of the Operational Monitoring Program is carried out for one or more subprograms, and it is necessary that one or more of the main objectives of the operational monitoring program is to be implemented at each sampling point.

The subprograms of the operational monitoring program for watercourses include the following items (tasks):

- OM1: to assess the effectiveness of measures aimed at reducing the impact of point sources of pollution (both individually and in combination, including organic pollution, the impact of eutrophication and priority pollutants;
- OM2: to evaluate the effectiveness of measures aimed at reducing the impact of diffuse (dispersed) pollution sources;
- OM3: to evaluate the effectiveness of measures aimed at reducing the impact of hydromorphological changes;
- OM4: to monitor water bodies with high and good state (status), which currently do not fall into the category of “under the threat” or “at risk”, to assess the effectiveness of the activities of the OM program aimed at maintaining the high and good state of water of water bodies - transboundary monitoring, which is carried out in the Dnieper basin at transboundary sections;
- OM5: to control water bodies at risk, located in protected areas.

Note: several water bodies of the same type were identified as “at risk” or “under possible risk” as a result of the same type of impact (similar types of pollution sources). Therefore, while making observations using the OM program, the selection of sampling points was made in such a way that the sampling points were representative of a group of water bodies.

Suggestions for optimizing the existing surface water observation network include additional sampling sites for the operational monitoring program (OM). 6 sampling sites have been identified on the Dnieper Basin Rivers within the territory of the Republic of Belarus for testing (verification) using the OM program. The results obtained are presented in table 4.2.

Table 4.2 – Proposed sampling sites for the operational monitoring program in the Dnieper basin in Belarus

№	River name	General characteristics of the water body	Expected status/ potential	Sampling site	Risk category	Subsystem of OM
1	The Berezina	SWB	satisfactory	Below Borisov	At risk	OM1
2	The Svisloch	SWB	satisfactory	Osipovichi	At risk	OM1
3	The Berezina	SWB	satisfactory	the entry	At risk	OM1
4	The Udoga	SWB	satisfactory	Cherikov	At risk	OM1
5	The Sozh	SWB	satisfactory	Below Gomel	At risk	OM1
6	The Uza	SWB	satisfactory	Berezovka	At risk	OM1

Research monitoring

The WFD implies conducting this type of monitoring on such surface water bodies that are classified as “under the threat” or “at risk” and have very specific features, which makes it difficult to achieve the required water quality of the water body.

The list of studied indicators in this case will be dynamic. If it is necessary to obtain information on the state of a water body due to the appearance of potential risks associated with the occurrence of specific pollutants, sources of exposure and any other changes, this list should be changed in a timely manner.

Groundwater

Suggestions for optimizing the existing groundwater observation network in the Dnieper Basin are based on the conceptual understanding of the underground hydrosphere, taking into account the existing national monitoring network and observation schedules, as well as taking into account the requirements of the Water Framework Directive (WFD) and the EU Groundwater Directive (EU GD).

An observational monitoring program is proposed for six groundwater bodies with good quantitative and chemical status (temporary codes from GW-01 to GW-06). The minimum number of groundwater observation points is three[13] (it is proposed to equip five monitoring wells in each groundwater object with uniform hydrochemical and hydrodynamic properties). Five monitoring sites (points) guarantee reliable characterization of the groundwater body[14]. It is proposed to maintain all available monitoring wells and rotate them every year to ensure the best territorial coverage of the analyzed Quaternary GWBs. The peculiarity of Belarus is soil contamination with radionuclides after the accident at the Chernobyl NPP. Contaminated areas should be covered by a surveillance monitoring program.

Table 4.3 – Proposed network of observational groundwater monitoring (quantitative and chemical)

№	Name and code of GWB	Number of monitoring wells	What is monitored	Monitoring objective
1	Marsh and peat GW-01	5 new monitoring wells (GW-01-1-GW-01-5)	the level and chemistry	Surface water interaction; protected zones and habitats of birds
2	Quaternary alluvial unpressured GW-02	44 existing wells with an annual rotation of 25 points/year	the level and chemistry	Feeding and discharge zones of GWB
3	Quaternary pressured intermorainal GW-03	42 existing wells with an annual rotation of 25 points/year	the level and chemistry	Feeding and discharge zones of GWB; the impact of water intake from Minsk GWBs “at risk”
4	Paleogene and Neogene GW-04	5 (3 existing wells + 2 new wells, GW-04-1, GW-04-2)	the level and chemistry	Feeding and discharge zones of GWB; transboundary with Russia and Ukraine
5	Cretaceous GW-05	8 existing wells +1 new transboundary well (GW-05-1)	the level and chemistry	Feeding and discharge zones of GWB; transboundary with Russia

[13] Holms and others.The EU Water Framework Directive: Statistical aspects of the identification of groundwater pollution trends, and aggregation of monitoring results"

[14] Irrigation Sector Reform Activity (ISRA) River Basin Management Sub-activity Identification, Delineation, and Classification of Water Bodies

6	Devonian GW-06	5 (1 existing well + 4 new wells, GW-06-1-GW-06-4)	watercourses and chemistry	Feeding and discharge zones of GWB; transboundary with Russia
7	Proterozoic GW-07	5 (2 existing wells + 3 new wells, GW-07-1-GW-07-3)	the level and chemistry	The impact of water intake from Minsk GWBs “at risk”
8	GWBs with potential radionuclide contamination	5 new wells?(GW-08-1-GW-08-5)	the level and chemistry	Radionuclide contamination after the accident at the Chernobyl nuclear NPP

Table 4.4 – Parameters of observational monitoring of groundwater and sampling frequency

Parameters and indicators	Frequency, not less
Main cations and anions (Na, K, Ca, Mg, Fe^{tot}, NH_4, HCO_3, Cl, SO_4, NO_3, NO_2) and physical properties (pH, conductivity, permanganate index or total organic carbon (TOC))	2-4 times per a year
Microelements (Fe, As, Hg, Cd, Pb, Zn, Cu, Cr и т.д.)	Each 2 years
Pesticides*	Each 6 years
Polycyclic aromatic hydrocarbons (PAHs), phenols, trichloroethylene (TCE), perchlorethylene (PCE)**	Each 2 years
Groundwater level in monitoring and production wells, flow rate and level in natural sources and streams	Electronic data loggers – every 6-12 hours. Other monitoring wells – 3 times a month. The debit and level of rivers – during sampling (2-4 times a year during the dry season)

Notes: * Pesticides should be analyzed only at monitoring sites located in agricultural areas; their selection depends on the structure of local land use and the probability of their detection in groundwater;

** PAHs, phenols, TCE и PCE should be analyzed in wells located in urban areas (Minsk, Gomel, etc.) and near industrial facilities. The specific selection depends on local sources of pollution.

Operational monitoring is advisable to focus on monitoring the objects of groundwater, confined to a risk group, establishing any long-term trends towards an increase in the concentration of pollutants induced through anthropogenic impact. The operational monitoring program can be proposed for the groundwater body around Minsk (code GW-07), which was assigned the “at risk” category due to overexploitation and the formation of a depression funnel. All other large water intakes in the Dnieper basin, which produce>100 m^3/day of groundwater, are also subject to operational monitoring to assess their impact on the underground and surface environment.

Research monitoring is needed in specific cases that require further research. Such monitoring can be proposed for the “Novinki” water intake in Minsk in order to detect the origin and source of contamination with nitrates.

The observation of the interaction of surface and groundwater is an important requirement of the WFD. It is well known that an increase of water extraction negatively affects surface waters – primarily, swamps, peatlands and small streams. The interaction of surface and groundwater is not a separate branch of monitoring. This interaction should be considered by all types of monitoring: observational, operational and research. In Belarus, several monitoring stations for natural regime also include surface water sampling stations. It is proposed to continue the sampling of surface water, paying more attention to surface water flow during periods of drought, when the rivers are fed mainly due to the discharge of groundwater.

The final suggestions for optimizing the existing groundwater observation network in the Dnieper basin in terms of observational monitoring, recommended parameters and sampling frequency are given in Tables 4.3,4.4.

7.3 Actions for determining the ecological status of surface water objects

7.3.1 Surface waters

According to clause 1 of Article 6 of the Water Code of the Republic of Belarus “The ecological state (status) of surface water bodies (their parts) is determined on the basis of hydrobiological indicators using hydrochemical and hydromorphological indicators”.

On the basis of the NEMS data and the field research conducted as part of the project of the EPIRB, the assessment of hydrochemical and hydrobiological indicators, as well as taking into account the degree of change in hydromorphological indicators, was carried out.

In accordance with TCCP 17.13-10-2013 (02120), TCCP 17.13-11-2013 (02120), TCCP 17.13-08-2013 (02120), TCCP 17.13-09-2013 (02120), SRB EN 14614-2012 the assessment of hydrobiological, hydrochemical and hydromorphological indicators **was made. The ecological state (status) of surface water bodies is determined in accordance with TCCP 17.13-21-2015 (33140).**

The analysis of chemical (hydrochemical) indicators was carried out on the basis of observations of the quality of surface water on hydrochemical indicators within the stationary network of NEMS based on 2012–2017 data and on single field studies of 2014 and 2015 conducted in the framework of the international project “Environmental protection of international river pools.

The quality class in terms of hydrochemical parameters is defined for 80 sections of watercourses (water bodies) after their identification, including areas where NEMS observation points are located. According to the results of the class assessment for the NEMS points, extrapolation and interpolation of the values to the water body section was carried out taking into account the occurrence of sources of influence on the hydrochemical regime and factors reducing their impact.

According to the results of calculations of chemical (hydrochemical) indicators, the following water bodies with a class are identified:

- the first class (excellent) – 10;
- the second class (good) – 58;
- the third class (satisfactory) – 12;
- the fourth and fifth classes (poor and very poor) weren’t outlined.

The satisfactory (the third) chemical (hydrochemical) class is set for the following areas of water bodies:

- the Svisloch river below Minsk to the mouth (BY010812/03, BY010812/04);
- the Loshitsa river within the boundaries of Minsk to the mouth in the Svisloch river (BY01081203) – based on the results of a single survey;
- the Plissa river (BY010805/01, BY010805/02);
- the Berezina river below Borisov to Svetlogorsk (BY0108/04, BY0108/05);
- the Drut river (BY0106/03) – based on the results of a single survey;
- the Sozh river below (BY0110/02) – based on the results of a single survey;
- the Uza river (BY011015);
- the Ut' river (BY011016) – based on the results of a single survey;
- Milchansk ditch at the confluence of the Uza river (BY01101501) – based on the results of a single survey.

It should be noted that the quality assessment of the watercourse water (section of the watercourse) according to the results of a single survey is not sufficiently reliable and preliminary. Additional detailed studies of the water quality of these water bodies are needed.

The second and first classes of chemical (hydrochemical) quality state are determined for the other water bodies.

In Dnieper basin objects that have the worse chemical state class than the third weren't detected.

Reference (standard or closest to natural conditions) conditions for the chemical (hydrochemical class) are determined by identifying water bodies that have an excellent (the first) class.

In the Dnieper basin in Belarus, the first class of chemical (hydrochemical) indicators is established for the following areas of water bodies:

- the Berezina river from the source to the city of Borisov (BY0108/01);
- the Lahva river (BY0104) – based on the results of a single survey;
- the Volches river (BY011005/01) – based on the results of a single survey;
- the Pokot river (BY011011) – based on the results of a single survey;
- the Deryazhnya (BY01101302/01, BY01101302/02) – based on the results of a single survey;
- the Dnieper river from Loev to the border (BY01/06, BY01/07).

The closest to the reference conditions is the area of the Berezina river from the source to Borisov, which is located in a large part of the Berezina Biosphere Reserve.

It should be noted that the attribution of a watercourse (watercourse section) to the standard category (the quality of which is closest to natural water quality) according to the results of a single survey is premature. A set of additional detailed studies of the water quality of these water bodies is needed.

The analysis of hydrobiological (environmental) indicators of the water bodies state was carried out on the basis of observations of the quality of surface waters using hydrobiological indicators on the stationary network of NEMS for 2012–2017, as well as on the results of single expeditionary studies conducted in 2013, 2014 and 2015 within the international the project "Environmental Protection of International River Basins".

The class of hydrobiological indicators is defined for 80 water bodies.

Among them 17 water bodies belong to the first class of indicators; 45 bodies belong to the second; and 16 have the third class.

The third class of hydrobiological indicators is established for the following sections of water bodies:

- the Dnieper river (BY01/01, BY01/03, BY01/04);
- the Gaina from the source to Logoisk (BY010803/01);
- the Drut river (BY0106/03) – based on the results of a single survey;
- the Sozh river (BY0110/02);
- the Adrov river (BY0103);
- the Udoga river (BY011006);
- the Zhadunka river below Kostyukovichi to the mouth (BY01101301/02);

- the Dobysna river (BY0107);
- the Uza river (BY011015);
- the Berezina river below Svetlogorsk to the mouth (BY0108/03, BY0108/05);
- the Plissa river (BY010805/02);
- the Porositsa river (BY01100804);
- the Svisloch river (BY010812/01).

The fourth class of hydrobiological indicators is established for the following sections of water bodies:

- the Svisloch river below Minsk from the settlement Korolischevich to the Osipovichi reservoir (BY010812/03).

According to the results of a single survey in 2015, the fifth class of hydrobiological indicators was defined for the Milchansk ditch (BY01101501), which is a tributary of the Uza River in the Gomel area within the Bobovichi settlement.

The second and first classes of hydrobiological indicators have been established for the other areas of water bodies.

Reference (standard or closest to natural conditions) conditions for hydrobiological indicators are determined by identifying water bodies, for which hydrobiological indicators are assigned to the first class.

In the Dnieper basin in Belarus, taking into account the results of the NEMS and single field research (see tables 13.2, 13.3 of Appendix A), first-class hydrobiological indicators have been established for the following sections of water bodies:

- the Skha river (BY010804);
- the Drut river (BY0106/01, BY0106/02, BY0106/04);
- the Resta river (BY01100803/02);
- the Volches river (BY011005/01, BY011005/02);
- the Chernaya Natopa river (BY011002);
- the Oster river (BY011003);
- the Senna river (BY011007);
- the Deryazhnya (BY01101302/01, BY01101302/02);
- the Pokot river (BY011011);
- the Kleva river (BY010810);
- the Plavno lake near Sloboda settlement.

The water quality of the listed small rivers, the class of indicators of which is determined on the basis of the field research carried out within the project, corresponds to the closest reference (natural) conditions.

There are no data on hydrobiological indicators for 28 water bodies; therefore, their ecological status is not determined.

According to the monitoring data for 2017, the quality class for most surface water bodies of the basin was estimated by hydrochemical indicators as excellent (73.2% of watercourses and 33.3% of reservoirs), good (9.8% of watercourses and 66.7% of reservoirs) and satisfactory (17.1% of watercourses).

The assessment of the ecological status of water bodies of the Dnieper River Basin, taking into account hydrochemical and hydrobiological indicators, as well as the degree of hydromorphological changes, is given in Table 13, 13.1, 13.2, in the final Table 13.3 of Appendix A and on map-scheme No.10 of Appendix B.

As a result, the classes and ecological status for 84 water bodies specified in the result of their inventory have been assessed. In addition to these objects, data on hydrochemical parameters are available only for 4 water bodies. The final excellent ecological state (status) is assigned to 3 water bodies. 59 water bodies have good status. 20 water bodies have satisfactory status. One water body has poor status and one water body has very bad status.

For surface water bodies of the Dnieper river basin, as well as the republics in general, the pervasive pollutants are nitrogen and phosphorus compounds. In recent years, a comparative analysis of hydrochemical data reveals only a slight decrease in the number of water samples contaminated with biogenic substances. Despite

the reducing trend traced over the last three years, the most "problematic" point is pollution of surface waters with phosphate ion, which remains a specific feature of surface water bodies of the Dnieper basin.

In 2017, a number of areas of watercourses were discovered. Their waters were characterized by the elevated concentrations of biogenic substances (nitrogen and phosphorus compounds) observed throughout the year with the pointing of an indicator whose value exceeds the MAC for 100% of water samples:

- the Plissa river above and below Zhodino – phosphate ion;
- the Svisloch river near Korolischevichi village – phosphate ion, ammonium ion, nitrite ion;
- the Svisloch river near Svisloch village – phosphate ion, nitrite ion;
- the Vedrich river above Babichi village – phosphate ion;
- the Uza river 5.0 km and 10.0 km south-west of Gomel – phosphate ion;
- the Loshitsa river within the city of Minsk – ammonium ion, nitrite ion;
- the Berezina river above and below Svetlogorsk– phosphate ion.

Over the past two years, the number of water samples with excess phosphate ion content has decreased (from 46.5% in 2016 to 32.93% in 2017), which indicates a slight decrease in the load on this type of pollutants.

In 2017, observations on hydrochemical parameters were carried out within 3 water objects: one lake (Orekhovsk) and two reservoirs (Vyacha, Petrovichi). Oxygen regime within most reservoirs of the Dnieper river remained satisfactory throughout the year.

7.3.2 Groundwater

Within the Dnieper river basin on the territory of Belarus seven underground water bodies are identified, six of which have good quantitative and good chemical statuses.

There are no deviations from free variations in groundwater levels within hydrogeological sites located in the territory of the Dnieper basin. At the same time, there is a tendency of an increase in the levels of both groundwater and artesian water. Analysis of the groundwater regime in natural and weakly disturbed conditions shows that there is a hydraulic connection between groundwater and artesian groundwater. Seasonal rises, drops and extreme levels of artesian water are identical to those of groundwater and often repeat each other (sometimes with some time delay).

Hydrogeochemical regime of groundwater. Assessment of groundwater quality in natural (weakly damaged) conditions is carried out in accordance with the Sanitary Rules and Regulations (SanPiN 10-124 RB 99 “Drinking water. Hygienic requirements for water quality of centralized drinking water supply systems. Quality control”).

Analysis of the study’s results of the hydrochemical composition of groundwater shows that more than 95% of groundwater samples correspond to SanPiN 10-124 RB 99.

Non-compliance with requirements of SanPiN 10-124 RB 99 for single samples on such indicators as increased contents of iron, manganese and low values of fluorine, iodine, permanganate oxidability is due to the influence of natural factors.

The influence of local (anthropogenic) sources of pollution (agricultural, household, industrial genesis) leads to the fact that there are elevated rates (sometimes higher than MPC) in pH, NO_3^-, NO_2^-, NH_4^+, total mineralization, total stiffness in the groundwater and artesian waters.

The most intensive source of groundwater pollution in the Dnieper basin for the country is agricultural activity (the use of mineral fertilizers, etc.), as a result of which groundwater samples show elevated indicators of total hardness, total salinity, oxidability of permanganate, nitrogen compounds.

The physical properties of groundwater comply with established standards. The pH index for groundwater varies in the range from 5.39 to 8.77 (with an average pH = 7.34). The pH value for artesian waters varies from 6.03 to 10.35 (with an average pH = 7.70). The temperature regime of ground and artesian waters ranged from 7.0 to 12.0 °C. In general, over the ten-year period until 2018, there has been no deterioration in the quality of groundwater under natural conditions.

8 ENVIRONMENTAL OBJECTIVES AND SOLUTIONS OF ENVIRONMENTAL ISSUES OF THE DNIEPER BASIN

The main solution of the environmental issues can be the implementation of measures to achieve environmental goals presented in Section 7 of this RBMP and in Table 21 of Appendix A.

The definition of environmental objectives is based on Article 4 (paragraphs 4.3-4.7) of the EU Guidance Document to the Water Framework Directive No.1 “Economy and the Environment. Issues of the realization of the Water Framework Directive.” In addition, the Republic of Belarus joined the Protocol on Water and Health (hereinafter referred to as the Protocol) by the Decree of the President of 31 March 2009 No.159. In the Republic of Belarus target values have been set for all ten sections of the Protocol.

Ecological goals for the water bodies of the Dnieper basin are based on the achievement of:

- a good ecological state (status) of surface water bodies;
- a good ecological potential of heavily modified surface water bodies (HMWB) and artificial water bodies (IWO);
- a good quantitative and chemical status of groundwater bodies.

Ecological targets for protected areas:

Until 2024:

- sanitary protection zones are confined to all water intakes with a volume of more than 5 m^3/day, including water intakes that are not included in the centralized water supply system (CSW);
- quality of 75% of intake of drinking water with an intake of more than 5 m^3/day is monitored at least once a year, including water intakes that are not part of the CSW;

Until 2030:

- the quality of 100% of intake of drinking water with an intake of more than 5 m^3/day is monitored at least once a year, including water intakes that are not part of the CSW;
- a good quantitative and chemical status of all drinking water with an intake of more than 5 m^3/day, including water intakes that are not part of the CSW.

Ecological targets for water bodies vulnerable to nitrate pollution:

Potential targets until 2024:

- vulnerable zones with regard to pollution by nitrates are identified and established;
- a code of best practice for the management of organic and mineral fertilizers, land management and a program of control and penalties has been developed, disseminated and implemented;
- a program for monitoring nitrates (surface waters and groundwater) is implemented.

Potential targets until 2030:

- 90% of the results of the monitoring program data show a nitrate content of less than 50 mg nitrate /dm^3.

Ecological goals until 2030 for water bodies used for recreation (bathing) are based on the good quality of all objects.

The implementation of the WRMP (Water Resources Management Plan) of the Dnieper basin with its approval in 2018 is planned to be realized in two stages.

The first stage (2019–2024) includes the implementation of priority activities. Their implementation will contribute to the maintenance of “good” or “excellent” ecological state (status) of water bodies and enable a progressive reduction of the negative decline in water bodies.

The second stage (2025–2030) includes additional measures. Their implementation will improve the ecological state (status) of surface water bodies that are at risk of not achieving a “good” ecological state (status).

Achieving ecological goals predetermines the need to prevent deterioration of the existing ecological status of surface water bodies, the support of excellent and good status of water bodies, and to 2024 and 2030 restore water bodies with a status worse than “good”, at least to "good" status.

In some cases, for some water bodies in the first six-year cycle of the implementation of the program of measures (and possibly in following cycles), environmental objectives cannot be achieved. According to Article 4 of the WFD, these cases are considered as exceptions.

Schematic map of environmental objectives for the two cycles of RBMP implementation is presented in the Appendix B (figure 27).

9 ECONOMIC ANALYSIS

9.1 Water balances

Water balances are calculated materials that allow comparing the need for water with the quantity and quality of available water resources at a given time in a certain area.

The purpose of compiling water management balances is the estimation of the sufficiency of water resources within the selected territory to meet the needs of water users, taking into account the prevention of depletion of water resources and deterioration of water quality in water bodies.

Water balances are compiled for river basins and water sites.

(Tables 6.1, 6.2).

Tables 6.1–The list and codes of water sites in the Dnieper basin

Code of water-resource region				Area name	Area number
sea-river	tributaries	L1*	L2**		
1	2	3	4	5	6
CHERNOE-DNIEPER		1645	1715	the Dnieper (Russian boundary - Orsha)	1
CHERNOE-DNIEPER		1554	1645	the Dnieper (Orsha-Mogilev)	2
CHERNOE-DNIEPER		1360	1554	the Dnieper (Mogilev - Drut)	3
CHERNOE-DNIEPER	1360	0	9999	the Drut	4
CHERNOE-DNIEPER		1245	1360	the Dnieper (Drut - Berezina)	5
CHERNOE-DNIEPER	1245	0	9999	the Berezina	6
CHERNOE-DNIEPER		1168	1245	the Dnieper (Berezina - Rechitsa)	7
CHERNOE-DNIEPER		1121	1168	the Dnieper (Rechitsa – Sozh)	8
CHERNOE-DNIEPER		0	9999	the Sozh	9
CHERNOE-DNIEPER		1010	1121	the Dnieper (Sozh - Ukranian boundary)	10

Note: * - the distance from the mouth of the river to the main-stream station;

** - distance from the mouth of the river to the entrance range.

Table 6.2 – The results of balance calculations for years of varying degrees of supply in the whole part of the Dnieper River within the Republic of Belarus, million m^3

Water balance components	the year of 95 % provision			the year of 75% provision		
	year	limiting period	high water period	year	limiting period	high water period
Receipts section						
	13570.4	1740.2	7605.9	15381	1940	9920
Disbursement section						
	4212.2	1001.2	976.7	4213	1002	977
The results of balance, B						
	9358.2	739.0	6629.2	11168	938	8943

The analysis of the results obtained for all the calculated years indicates that the extraction of flow from the river bed at the present time does not exceed 6% of the annual flow of 95% of the supply in the entrance range to the Republic of Belarus, therefore, any flow extraction cannot have any significant effect on the change of the river flow regime.

The growth of irreparable seizures planned for the future will not exceed 10% of the flow of 95% of the supply, which is also within the measurement accuracy of determining hydrological quantities. Nevertheless, water management balances over the years of 50%, 75% and 95% of the calculated water supply are estimated and the results are shown.

The analysis of the water balance, made for a low-water year of 95% of provision per a month, indicates that the water balance of the river for the year as a whole and at all intervals for the basin The Dnieper is favorable, and it provides both all utilitarian needs when withdrawing river water, and the preservation in the river of sufficient volume of water for environmental purposes.

However, in some months of the summer period, some intensity in the water balance can arise within the Dnieper tributaries due to the need to comply with nature conservation requirements, which indicates the necessity to pay special attention during these periods to the state of the quality of the wastewater being abstracted due to the reduction in the diluting capacity of the watercourse.

The final water management balance of the Dnieper basin, taking into account the characteristics of water use from surface and groundwater bodies for various needs, according to data for 2017, taking into account the flow volumes flowing in and flowing out of Belarus, is given in Table 2.3. The results of the water balance show a high provision of the basin with surface and underground water resources. The impact on these

resources of extractions from surface water bodies (no more than 4%) and extraction from groundwater bodies (no more than 34% of annual operating reserves, 3% of proven natural resources and 2% of predicted operating resources) is not significant.

The quantitative balance between water extraction from surface water sources and abstraction from groundwater sources and resources of surface and groundwater shows a high degree of provision of the basin with surface and groundwater resources.

The impact of water use on these resources is not significant: according to data for 2017, the extraction from surface water bodies is no more than 4%, according to data for the last twelve years it is not more than 9%.

Water intake from groundwater bodies in 2017 and over the past twelve years is no more than 3% and 5% of the natural explored groundwater resources and no more than 35% and 40% of their approved operational reserves, respectively.

Table 2.3 – The total water balance of the Dnieper basin by the flow volume formed within Belarus (surface waters) and natural fresh groundwater resources, taking into account the characteristics of water use from surface and groundwater bodies for various needs (according to 2017 data)

surface water - resources and extraction, million m^3/%			groundwater - resources and extraction, million m^3/ %			
flow volume formed within Belarus (surface water has low-water conditions, 95% probability of exceedance), million m^3/year	withdrawal for various needs, mln.m^3	% of runoff forming within Belarus	abstraction for various needs, mln.m^3	operational reserves million m^3	prospected natural resources, million m^3	prospected operational resources, million m^3
5615.001				1112.29	18521.00	25246.00
Water use characteristics				%	%	%
industry	41.605	0.74%	25.063	2.25%	0.14%	0.10%
energy	31.134	0.55%	2.576	0.23%	0.01%	0.01%
agriculture	43.486	0.77%	39.136	3.52%	0.21%	0.16%
fish industry	41.714	0.74%	1.315	0.12%	0.01%	0.01%
housing and communal services	11.571	0.21%	253.042	22.75%	1.37%	1.00%
other activities	5.021	0.09%	19.751	1.78%	0.11%	0.08%
water loss during transportation	1.030	0.02%	36.368	3.27%	0.20%	0.14%
total extraction and abstraction of water	175.561	***3.13%***	377.251	***33.92%***	***2.04%***	***1.49%***
remaining water resources	5439.440	96.87%	1112.290	66.08%	97.96%	98.51%

9.2 Weight of economic activities in the river basin

Economic activities and main uses from data available from the previous chapter are described as in the synthetic tables below. They guide the choice of measures and their impacts on economic activities.

Table 7.3 – A generalized economic analysis of the characteristics of the use of water resources and anthropogenic pressures, taking into account the rates used in water supply and sanitation and trends in these characteristics

Directions of use and loads	area	population	drinking water supply	agriculture	industry	fishery	energy	hydropower	tourism	navigation
Significance (weight) of the Dnieper basin according to different characteristics (% of Belarus), *including by regions:*	30.70	50.39	59.41	18.29	35.79	12.84	41.26	32.41	54.65	54.08
the Vitebsk region	3.19	2.33	2.67	0.92	2.16	1.04	1.86	General indicator on RB	14.53	General indicator on RB
the Gomel region	8.40	10.58	9.99	2.78	10.36	1.26	5.36		13.27	
the Minsk region and Minsk	6.33	26.70	34.03	7.83	12.46	9.35	24.33		20.06	
the Mogilev region	12.78	10.77	12.72	6.76	10.81	1.19	9.71		6.79	
Rates in the pool (water supply), equivalent in EUR, excluding VAT, *including by regions:*	-	0.34-0.38	0.27-0.67	0.39-0.67	0.27-2.44	-	0.39-0.67	-	-	-
the Vitebsk region	-	0.38	0.67	0.67	0.43-1.90	-	0.67	-	-	-
the Gomel region	-	0.38	0.52	0.52	0.38-2.44	-	0.52	-	-	-
the Minsk region	-	0.37	0.27	0.43	0.27-1.72	-	0.43	-	-	-
the Mogilev region	-	0.37	0.39	0.39	0.33-1.66	-	0.39	-	-	-
Minsk	-	0.34	0.27	0.43	0.27-1.72	-	0.43	-	-	-
Rates in the pool (water discharge), equivalent in EUR, excluding VAT, *including by regions:*	-	0.22-0.32	0.20-0.56	0.30-0.56	0.20-0.56	-	0.30-0.56	-	-	-
the Vitebsk region	-	0.29	0.56	0.56	0.41-0.56	-	0.56	-	-	-
the Gomel region	-	0.32	0.46	0.46	0.46-0.52	-	0.46	-	-	-
the Minsk region	-	0.29	0.20	0.30	0.20-0.30	-	0.30	-	-	-

Directions of use and loads	area	population	drinking water supply	agriculture	industry	fishery	energy	hydropower	tourism	navigation
the Mogilev region	-	0.28	0.32	0.32	0.26-0.37	-	0.32	-	-	-
Minsk	-	0.22	0.20	0.30	0.20-0.30	-	0.30	-	-	-
Tendencies		linear, stability	linear, stability	increase	linear, stability	linear, stability	linear, stability	increase	increase	decrease, slight decrease

Table 7.4 - Type of loads and trends in areas of use and loads*

Population	Significant load - a great number of residents of the Republic of Belarus is concentrated
Drinking water supply	Significant load - about 60% of water is used for drinking needs, of the total use for drinking needs
Agriculture	Insignificant - agricultural use of water for irrigation, land moistening, etc. does not exceed 20% of the national indicator
Industry	Significant load - large industrial enterprises are concentrated in the Dnieper basin, respectively, a significant amount of water is used for industrial needs, including for the production of various drinks
Fishery	Significant load
Energy	Significant load
Hydropower	Significant load
Tourism	Significant load
Navigation	Significant load

* - Table 7.4 is an addition to table 7.3

10 ACTIONS AIMED AT IMPROVING THE ECOLOGICAL STATE (STATUS) OF SURFACE WATER OBJECTS (PROGRAMME OF MEASURES)

The measures within the Dnieper RBMP include general-purpose measures (basic measures) and measures for specific water bodies aimed at improving their ecological state (status) and maintaining of excellent or good status of water bodies, including priority and additional measures (Table 21 of Appendix A).

The basic measures determine the main strategic directions in the field of the protection and use of water resources in relation to the Dnieper basin, and are the basis for these priority and additional measures. The characteristics and list of basic activities are presented below in this section.

Measures aimed at reducing the flow of pollutants into water bodies from point and diffuse (dispersed) sources of pollution.

The set of these water preservation measures includes the following activities:

- reduction of reservoir capacity production and prevention of diversion of untreated and insufficiently treated wastewater into water bodies;
- the introduction of advanced technologies that reduce the volume of wastewater and the amount of pollutants in their composition;
- measures for the sewage sanitation such as cleaning all types of sewage water (industrial, municipal, livestock farm sewage, surface wastewater);
- measures carried out directly in water bodies such as sanitary releases from reservoirs, aeration, cleaning the water surface from floating impurities;
- measures aimed at reducing the anthropogenic load on a water body due to a possible decrease in production volumes and improvement of the location of production facilities in river basins and in water management areas;
- improving the accounting of water resources and their use in terms of clarifying the binding of water user facilities and their wastewater discharges to water sources and to water bodies that receive wastewater;
- re-equipment of water users with modern measuring instruments;
- accounting for the discharge of pollutants through rainwater drainage systems;
- preparation of water management and hydrochemical balances for large industrial centers;
- development of the scientific and methodological framework for managing the use and protection of water bodies, including the development of cost-effective mechanisms for promoting efficient water use;
- development of the observation network for the state of water bodies and water management systems, including the state network for observing the state of surface and groundwater of the NEMS of the Republic of Belarus in terms of combining observations of quantitative and qualitative indicators of surface water;
- development of methodological and regulatory support for imitational mathematical models for estimating the intake of pollutants from dispersed (diffuse) sources of pollution and their impact on water bodies, the performance of appropriate assessments;
- identification of areas which are subjected to flooding, their classification and mapping;
- elaboration and development of basin geographic information systems;
- development and implementation of educational programs.

When implementing these measures, environmental criteria may receive priority over economic criteria in some particular cases. However, within the Republic as a whole, investment in water protection measures is significantly less than preventable damage.

The measures to improve the operational management of the use and protection of water bodies include the following types of measures:

– development of automated management systems for the use and protection of water bodies based on the introduction of tools for mathematical modeling and estimating the state of the river basin, the full and operational use of data from state monitoring of water bodies, and state control and supervision of the use and protection of water bodies;

– development of systems for immediate information and notification of the executive authorities, local governments, water users and the public on the state of water bodies and the threats of harmful effects on water.

In general, according to the reported data, the throughput of sewage treatment plants is greater than the volume of wastewater. However, a part of the wastewater is discharged into polluted water bodies. This is due to the lack of local sewage treatment plants within individual facilities, overloading of sewage treatment plants because of the mass of pollutants, inconsistency of sewage treatment technology, in particular, diversion of a large amount of industrial effluents to municipal sewage systems, as well as disruptions in the operation of sewage treatment plants.

Looking forward, it is planned to exclude disposal of polluted and insufficiently treated wastewater into water bodies. It is necessary to expand and reconstruct the city treatment facilities of the regional centers. In addition, it is provided for the organization of local treatment of industrial wastewater at enterprises (including agricultural), the purification of municipal wastewater after the complete biological treatment facilities. It should be noted that the specific investment expenditures for urban sewage are 15–20 times higher than for recycled water supply systems.

To prevent pollution of river waters by surface runoff from urban areas, it is necessary to carry out sewage and purification of rainwater, primarily within industrial sites, streets with heavy traffic, areas of high-rise buildings, etc.

Surface runoff from agricultural land is also a threat for water bodies from the point of view of their pollution. It contains nutrients that disrupt the ecological balance of the water body. The compliance with the norms and technologies of fertilizer application, the rules of their storage, the choice of a rational structure of crops on the coastal slopes, the creation of protective forest strips along water course contribute to the prevention or reduction of such pollution.

It must be distinctly noted the need for water protection measures to achieve/maintain the "good" or "excellent" ecological status of small transboundary watercourses in the Dnieper basin: the Vyazovka, Mereya, Iput, Resta, Vitava, Kolpita, Besed, Oleshnya, Desenka, Paluzh, Dorogovsha, Otchesa rivers[15].

In addition to the above measures, within the basins of these transboundary watercourses, it is advisable to foresee:

- the organization of an additional permanent observation point for hydrochemical, hydrobiological and hydrological indicators on the Vitava river in the Mogilev Region;

- the organization of additional observations on hydrochemical, hydrobiological and hydrological indicators on the Vyazovka, Mereya, Resta, Kolpita, Oleshnya, Desenka, Paluzh, Dorogovsha, Otchesa rivers.

In 2016-2018, a project program was developed for the modernization and reconstruction of the Minsk Wastewater Treatment Plan[16]. The European Bank for Reconstruction and Development (EBRD) considers the possibility of providing a loan for the implementation of this project. The total cost of the project is estimated at 168 million Euros. According to the results of the technical, environmental and social analysis, the following Project scope was

[15] Research report on «To conduct an inventory of water bodies of the Republic of Belarus on the instructions of the SSTP (state scientific technical program) « Environmental Safety», 2012–2013, RUE «CRICUWR», under the guidance of E.E. Petlitskiy, 20090148

[16] Information on the investment project of the Minsk WWTP, electronic source: https://minskvodokanal.by/reconstruction-mos/

determined: the reconstruction of the purification plant of WWTP-1, including the dismantling of unused facilities, and the construction of a sludge processing complex, which includes fermentation, dehydration, drying and incineration of sludge to produce heat and electricity energy for WWTP's own needs. This project includes the implementation of the following activities:

- the modernization and reconstruction of selected technological and secondary facilities, utilities, equipment (sinkers, sand traps, aerotanks, pumping stations, etc.) to increase the efficiency of wastewater treatment from pollutants, energy efficiency and reliability of the WWTP;
- the overlapping of open mechanical cleaning facilities and arrangement of the system for collecting and removing waste gases of buildings and structures of WWTP-1 (receiving room, bar screen buildings, sand traps, primary sinkers, channels for transporting waste water between facilities) and their distribution to a new air purification complex to reduce unpleasant odors;
- the introduction of nitri- and denitrification technologies which will ensure the biological removal of phosphorus and nitrogen from wastewater and generally improve the quality of wastewater treatment, which will significantly reduce the intensity of eutrophication processes in the Svisloch river;
- the introduction of an automatic control system for cleaning processes to increase the controllability of the treatment facilities and the reliability of technological processes;
- the introduction of a disinfection system for wastewater using ultraviolet radiation in a unpressured installation which will ensure the safety of treated wastewater;
- dismantling of groups of structures whose operation has been stopped (sludge digesters, contact tanks, etc.) or which are inefficient (sand pits, open sewage canals, sand traps, etc.).

Measures aimed at rational (sustainable) use of water resources and reducing the negative impact of other sources leading to the deterioration of the ecological state (status) of water bodies.

These activities include measures to improve production processes the purpose of which is reducing the water-intensiveness of production, developing and implementing water reuse systems and closed water recycling systems. The richest possibilities in the implementation of these activities are available in industry. Along with the production systems of circulating water supply, the possibility of prospective reuse of the treated municipal wastewater as a source of technical water supply, the use of agricultural irrigation fields can be considered.

According to the National Strategy for Sustainable Social and Economic Development of the Republic of Belarus for the period up to 2030 (NSSD 2030), the index of discharge of insufficiently treated wastewater into water bodies in relation to 2015 by 2025 should be no more than 50%, by 2025 no more 30%. By 2030 there should not be discharges of insufficiently treated wastewater.

According to the State program "Comfortable housing and favorable environment", the provision of consumers with drinking water supply should be 100 percent by the end of 2020.

The solution of the issues of the most complete water supply of the population, industry and agriculture is achieved not only by increasing the attracted water resources, but also by regulating water necessity, as well as by maximizing the reduction in non-production water losses, i.e. implementation of measures for water saving in the process of water use.

In industry, the main measure in this category is the introduction of water-saving technologies and the expansion of water reuse. It should be noted that these measures are now becoming increasingly common in the republic. This, in particular, is supported by the fact that the growth in water consumption for production purposes is lagging behind the growth in production volumes, and in a number of cities fresh water intake for industrial needs has practically stabilized.

At the same time, there are still large reserves of water supply. The development and implementation of shallow and waterless technological and secondary processes is a key direction in reducing the industrial water demand. At the same time, the improvement of the production process technology with regard to water conservation may require both a slight change in its stages, and a fundamental reconstruction of the process in the whole. The difference in possible techniques is due to the diversity of production units.

Large reserves of production are available in almost all sectors of the economy, as evidenced by the analysis of specific water consumption standards.

A very effective means of reducing fresh water consumption for production needs is water reuse. According to NSSD-2030, the use of water in the circulating and recurrent water supply systems for the entire period 2015-2030 should be at least 93.5% of the total water use for industrial needs. Reuse of water can be carried out according to different schemes:

- its consequential use in related production processes at the facility;
- recycling water supply of the same consumers;
- use of wastewater of some objects for technological water supply of other water users;
- use of urban and other categories of wastewater after appropriate water treatment as a source of industrial water for industrial enterprises, on agricultural irrigation fields, etc
- combined water supply scheme (as a combination of the above mentioned schemes).

The choice of one of these schemes is determined by the production technology, local conditions and is substantiated by technical and economic calculations.

One should be focused on the maximum return of water to production in all cases when it does not cause deterioration of product quality and it is economically justified. For this, existing reserves should be identified and used such as intensification of exploitation regimes of circulating water supply systems by increasing the concentration ratio, attracting new categories of wastewater as a source of technical water supply, for example, using water as a transporting medium, extragents, etc. The possibilities of transfer and intake of treated wastewater as a source of technical water supply should be considered, if they meet the necessary requirements, id there is a need to use treated wastewater for this purpose.

Saving water in communal services is achieved by reducing losses in water supply systems due to leaks, preventing accidents, and rational use of water by consumers.

The management mode of the pressure in the network contributes to the decrease of losses. For this purpose, zoning of water pipelines is used when there are large differences in terrain marks. Installation of water pumping stations in high-rise buildings, control tanks and chokes, automated systems for managing water supply networks are also used. Losses in the network also depend on the quality of construction and installation works and the materials used.

Significant water savings are also achieved with individual metering of water.

Thus, now it is possible to influence on demand as well as on the resources. In water use, these two areas are complementary or alternative. The choice of means contributing to water conservation is quite large and includes measures of a technical, administrative, legal, economic and social nature.

Legislative and administrative aspects of water management within the framework of the issue under consideration include, in particular, the necessity for each water user enterprise to have mandatory statistical reporting, as well as rationing and planning water consumption taking into account scientific and technical progress in this area. The main tasks in this direction are the improvement of the scientific and methodological basis for substantiating decisions made on the basis of a systems approach and computerization of calculations, taking into account the feedback “disposable water resources” – “water demand”. In addition, the content and accuracy of the incoming source information has a significant impact on the decision-making process.

The involvement in the fuel and energy balance of local types of fuel and energy resources and renewable energy sources is one of the priorities. In this direction, it is advisable to introduce biogas units, build new hydroelectric power plants, taking into account the assessment of their impact on the environment, as well as reconstruct existing hydroelectric power plants, build wind power plants, introduce heat pumps to use secondary low-grade energy resources and geothermal energy, introduce solar water heaters and solar power plants, etc.

One of the features of the future period is the increasing role and a much wider practical application of economic measures in the process of regulating water use.

For this purpose, an analysis of strengths and weaknesses in the field of water resources management, as well as opportunities and threats from the external environment (SWOT analysis) used in international practice can be applied. The results of the simplified "SWOT – analysis" in the most generalized form with respect to the use of water resources are presented in Table 7.1.

Table 7.1 - Strengths and weaknesses in the field of water use[17]

Strengths	Weaknesses
Water supply	
+ Nearly full coverage of water supply services is in the cities. + Continuous, reliable, day-and-night water supply is provided nearly everywhere. + Medium volumes of water consumption. + High level of service availability, including for the poor people.	– Issues related to water quality (increased iron content in the water distribution network). – The inconsistency of water quality by nitrates in the pit wells in rural areas. – Insufficient coverage of centralized water supply services in rural areas.
Water discharge	
+ Significant services availability cities. + A high level of compliance with standards in the purification from organic pollutants.	– Insufficient number of facilities for pre-purification of industrial wastewater.

The main economic instrument should eventually be a payment for the use of water in accordance with real costs. In this case, the rates should take into account the volume of water use, territorial and seasonal differences, sources of water supply, etc. Economic measures also include dotations, subsidies for improving the water sector, tax incentives for income spent on these goals, encouraging and stimulating workers for rational use of water.

Institutional measures in the field of rational (sustainable) use and protection of water resources and reducing the negative impact of other sources leading to deterioration of the ecological status (status) of water bodies can include the following activities:

– measures aimed at compliance with the established limits for water extraction from water bodies and groundwater sources and discharge of wastewater;
– development of the regulatory legal framework and technical legal framework for the regulation of water use (revision or improvement of regulatory legal acts and technical regulatory legal acts) necessary to improve the water management system;
– development of rules, programs, action plans in cases of extreme low water and extremely high water content (including timely hydrological forecasts, maps of hazards and flood risks, regulation of water distribution and use of backup water sources, improving the reliability and efficiency of water supply systems, identification of alternative or additional sources water supply) taking into account adaptation to climate change;
– development of rules for regulating land use in water protection zones of water bodies (including their arrangement and improvement) and watersheds in order to prevent pollution and depletion of water bodies;
– preparation of justifications for setting fees for the use of water bodies, stimulating the rational use of water bodies;
– preparation of justifications for the development of insurance systems for risks associated with the harmful effects of water.

Basic activities based on their general characteristics, presented above, are shown in Table 7.2.

[17] analysis of strengths and weaknesses prepared using the results of the study of the water supply and wastewater sector in the Republic of Belarus, carried out by experts of the International Bank for Reconstruction and Development with the participation of Belarusian experts, June 2013, 92 p.

Table 7.2 – List of general-purpose measures (basic activities)

Measures	Terms of implementation
Measures to apply the compensation for water use costs	
Development of regulatory instruments for the rational and careful use of water resources, improvement of the financial and economic mechanism for encouraging the introduction of best available technical methods (BAT)	2019–2024
Development of systems for the control and supervision of the use and protection of water bodies	2019–2024
Development of the regulatory and technical base for the use of water resources and regulation of water use	2019–2024
Improving the pricing policy for water in order to exclude unreasonable use of drinking-quality water for the industrial enterprises' technological needs	2019–2024
Measures to promote efficient and sustainable water use	
Coordination of activities and information exchange between environmental protection and other organizations, business entities of administrative units operating in the Dnieper basin	2019–2030
Formation of regional activities and programs in the field of water protection and use based on the RBMP (Article 13 of the Water Code)	2019–2024
Publication of the Dnieper River Basin Management Plan on the website of the RUE "CRICUWR" and executive committees	2018
Development of design documentation for the improvement of reservoirs	2019–2030
Development and adoption of measures to provide the population with drinking water, including the construction of deferrization stations	2019–2025
Monitoring compliance with the regime of economic and other activities established for water protection zones and coastal zones	2019–2030
Introduction of circulating and re-sequential water supply systems in order to reduce the amount of discharged wastewater and reduce the water needs associated with its production (extraction) (Article 42 of the Water Code)	2019–2024
Reduction of water losses during its transportation and use at enterprises	2019–2024
Elimination of the use of drinking water quality for production needs and reduction in cases where this is allowed in accordance with the laws of the Republic of Belarus	2019–2024
Development of industry technological standards for water consumption and drainage for various industries	2019
Development (adjustment) of individual technological standards of water consumption and water disposal for enterprises	2019–2030
Organization of instrumental metering of intake, produced, extracted and discharged water by entities engaged in water use	2019-2024
Organization and optimization of the observation network for the hydrological and hydromorphological regimes of water bodies, including the installation of automated measurement tools	2019–2030

Measures	Terms of implementation
Development of the observational network for the state of water bodies and water management systems	2019–2030
Development of a computer system that allows working with spatially distributed information on the river basin and the activities carried out within its borders that affect the water resources (basin geo-information system)	2019–2024
Assessment of the possible degree of development of hazardous hydrometeorological phenomena within water bodies (spring floods and summer-autumn rain floods; dry periods)	2019-2020
Identification of areas which are subjected to flooding, their classification and mapping. Development of flood risk assessment maps in accordance with the approaches of EU Directive 2007/60/EC	2020-2024
Inventory of existing polder and amelioration systems in the basin, assessment of their effectiveness, safety and environmental impact with the development of recommendations for their improvement	2019–2024
Instrumentation of posts for operational automatic control of the level regime of the rivers of the Dnieper basin	2019–2030
Development of an early warning system based on the operational data of automatic control of the level regime of the rivers of the Dnieper basin	2019–2030
Groundwater intake protection measures	
Organization and improvement of the observation network of wells of potentially dangerous sources of pollution	2019–2030
Measures to control the state of water intake and replenishment of surface waters and groundwater	
Control over the use of water objects for their specific purposes, as well as observance of the rules for the technical operation of hydraulic structures and devices, maintaining them in good condition	2019–2030
Organization and implementation of accounting of produced groundwater, withdrawn surface water and wastewater discharged into the environment	2019–2030
Construction and replacement of water and sewage conduits and networks	2019–2030
Development of scientific and methodological base for managing the use and protection of water bodies	2019–2024
Determination of areas of overflow and flooding of areas leading to economic damage due to flooding	2020–2024
Tamping and liquidation of non-operating water wells	2019–2030
Measures to control point and diffuse sources of pollution	
Reconstruction of local treatment facilities	2019–2030
The implementation of modern technologies of wastewater purification from nutrients at the facilities	2019–2030
Provision of surface wastewater treatment in settlements with a population of more than 50 thousand people, in resort and industrial areas	2019–2024

Measures	Terms of implementation
Introduction of BAT (best available techniques) in agriculture	2019–2024
Regulation of the use of areas which are potentially subjected to flooding	2019-2024
Regulation of land use in water protection zones	2019–2030
Specification of the boundaries of water protection zones and coastal areas of water bodies located within the river basin within the framework of the development and adjustment of projects of water protection zones and coastal areas of water bodies	2019–2024
An inventory of livestock facilities located within the territory of water protection zones for equipped water-proof manure stores, liquid manure pit and other devices and structures that prevent contamination, water pollution, with an organized drive for the transportation (removal) of the contents of these devices and structures	2019-2020
Justification for the placement of livestock facilities, taking into account topographical, hydrological and soil conditions of the area	2019–2024
Evaluation of the effectiveness of the municipal treatment plants and the development of recommendations to improve their efficiency	2019–2024
Analysis of the state of temporary storage of snow in winter	2019–2020
Measures for authorizing direct discharge into groundwater	
Reduction of the operation of filtration fields with their subsequent recultivation with a flow volume of more than 200 m^3/day	2019–2024
Calculation of appropriate volumes of groundwater extraction for the needs of water supply in large settlements	2019–2024
Measures to manage priority substances	
Technical re-equipment of surface and groundwater monitoring network	2019–2023
Reconstruction of sewage treatment plants in plating industry	2019–2024
Implementation of obligations on international conventions	2019–2030
Measures to control the hydrochemical composition and quality of surface and groundwater	
Improvement of recreation areas within water bodies	2019–2030
Development of observation program of the hydrological and hydromorphological regimes of water bodies	2019–2020
Elaboration and development of basin geo-information systems	2019-2020
Extensive beach protection and shore protection works	2019–2030

Measures	Terms of implementation
Ensuring the reliability of hydraulic structures	2019–2030
Development of systems for the control and supervision of the use and protection of water bodies	2019–2030
Integrated development of surface water monitoring and groundwater monitoring and optimization of the monitoring network and monitoring regime for groundwater regime and quality	2019–2030
Implementation of activities of the State program "Environmental Protection and Sustainable Use of Natural Resources" for 2016–2020	2019-2020
Measures that control any other actions that can affect the ecological status of water bodies	
Control and supervision over the use and protection of water bodies	2019–2030
Ensuring the development and maintenance of the state water cadastre	2019–2030
Performance of engineering works for ensuring safe conditions of navigation on inland waterways	2019–2030
Construction of biogas energy sources	2019–2030
Separate collection of SMW (solid municipal waste) in settlements	2019–2024
Liquidation of unauthorized landfills of SMW	2019–2030
Development and implementation of educational programs aimed at raising the level of information and raising the level of knowledge of the broad population on the state of water resources, their rational and careful use	2019–2024
Public participation in the development, implementation and monitoring of activities	2019–2030
Creation and development of the system of environmental education and education of the population. Involving the public in the decision-making process in the use and protection of water bodies. Providing access to information for different population groups	2019–2030
Development of technological regulations on the assessment of pollutants from dispersed (diffuse) sources of pollution	2019-2020
Development of technical regulations, determining the conditions of location of livestock farms and farms within the boundaries of water protection zones	2019–2020
Implementation of climate change adaptation measures	2019–2030

Table 21 of Appendix A represents measures for specific water bodies aimed at improving their ecological state (status) and maintaining water bodies which have excellent or good status, including priority and additional measures.

Totally, 36 priority measures have been proposed for the first cycle of the implementation of the Dnieper RBMP with a total cost of approximately 233 million Euros, of which 168 million Euros (more than 70%) are activities for the Minsk Wastewater Treatment Plan). The gross domestic product (GDP) in the Dnieper basin in 2017 and the six-year cycle of the RBMP implementation will be approximately no more than 0.2% per a year of GDP created in the Dnieper basin[18,19]. For the second cycle of the RBMP implementation, the realization of the proposed 27 additional measures with an estimated cost of up to 26.0 million Euros will be approximately not more than 0.02% per year of GDP created in the Dnieper basin.

General map of the Program of Measures for the Dnieper basin is given in Appendix B (figure 28). The distribution of measures is given take into account number of measures for corresponded water bodies and term of their realization.

The importance of measures is determined by the degree of significance (weight) of the Dnieper basin according to various characteristics, including the basin area, the number of population, as well as the types of uses and loads and the difference in applied rates in these areas (see part 6).

[18] https://benefit.by/info/vvp/ - data on GDP in Belarus

[19] Belarus's GDP for 2017 amounted to 105.199 billion rubles or the equivalent of $ 48.126 billion (41.87 billion Euros), taking into account the conversion to the Dnieper basin in terms of per capita GDP and the number of inhabitants in the GDP basin created in the Dnieper basin in 2017, can be estimated at approximately 21,1 billion Euros.

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